Sewage Works Journal

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Sewage Works

HOURLY VARIATIONS OF SEWAGE CONCENTRATION AND FLOW *

By Walter A. Sperry

Superintendent, Aurora (Illinois) Sanitary District

In Chapter Two of his book *Sewage Treatment Works* C. E. Keefer enumerates five major and thirteen minor reasons for determining the quantity of sewage flowing to a treatment plant. Suffice it to say that all these reasons are important and too well known to enumerate here.

It is the purpose of this paper to display, with a few brief comments, a study of the dry weather sewage flow as received at the Aurora, Ill., plant (Figures 1 and 2). The curves have added interest by showing simultaneously the suspended solids and 5-day B.O.D. contents observed.

Before discussing these curves it might be well to state that the Aurora plant is situated on the Fox River and about five miles below the center of the city. This plant location was chosen, in part, because it made possible complete gravity flow of sewage from the city to the plant, thus eliminating the need for and the cost of high-lift pumping. The only sewage pumped in the city is that collected on an island in the river, which is passed to the interceptor on either side by two small lift stations.

A second observation on Aurora sewage that may be helpful in appraising these curves is the fact that practically all the industries in Aurora are engaged in metal fabrication. The sewage collected, therefore, is generally domestic in character.

The data for these curves were gathered between the dates of July 15, 1942, and September 10, 1943. During this period, as time, incubator space and weather conditions permitted, ten 24-hr. studies were made of the typical dry weather flow for each day of the week. During each day under study, samples were collected at 2-hr. intervals beginning at midnight and continuing throughout the 24-hr. period. These samples were analyzed for suspended solids and 5-day B.O.D. content and, when ten typical Mondays or Tuesdays had accumulated, the final results were averaged and plotted.

When the work had progressed to a point where five complete studies had accumulated for each day of the week the results were averaged and plotted. It was predicted that these curves would not differ sufficiently from the 10-day study contemplated to make it necessary to continue the work. It was felt, however, that the 10-day study should be completed, as originally planned, in order to get a more accurate average. As predicted, however, the 10-day curves, exhibited herein, proved to be almost identical with the 5-day partial study. Figure 1 presents these curves in detail for the 7 days of the week. Figure 2 presents the same data reduced to averaged summary curves.

Among the many interesting features

* Presented at the 18th Annual Meeting, Central States Sewage Works Association; Lafayette, Indiana; June 13–14, 1946.

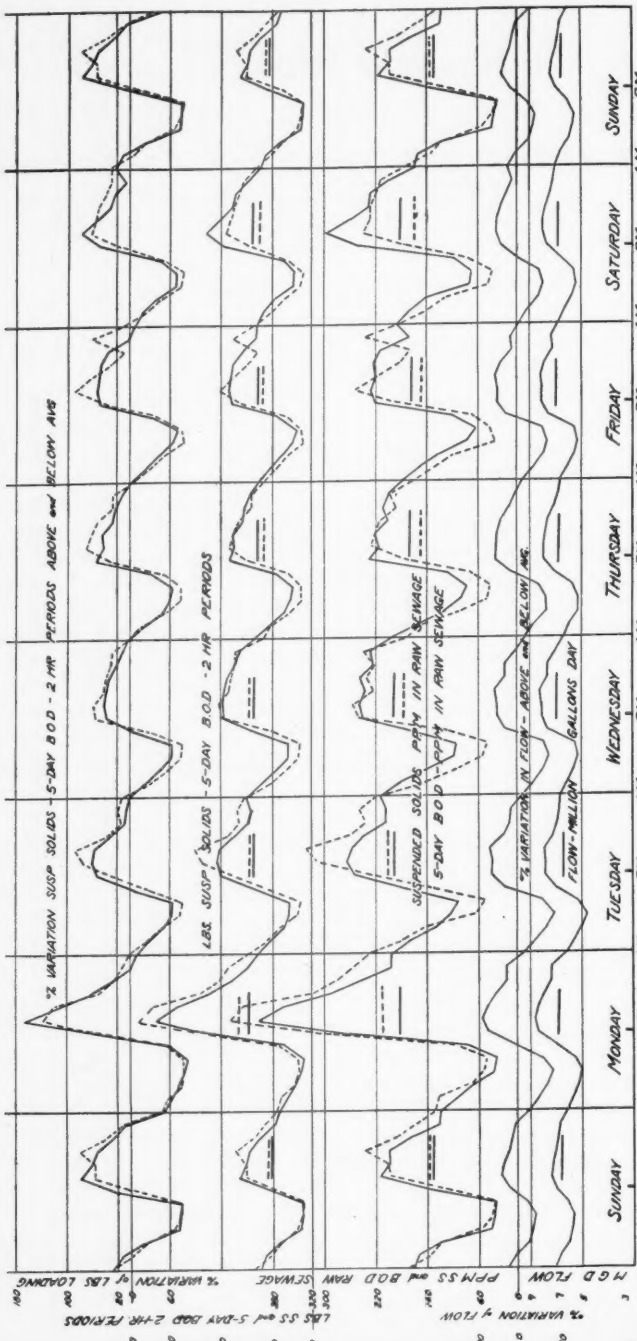

FIGURE 1.—Curves illustrating flow and load variations by 2-hr. periods for each day of the week and based on the average of ten typical "dry weather" flow days.

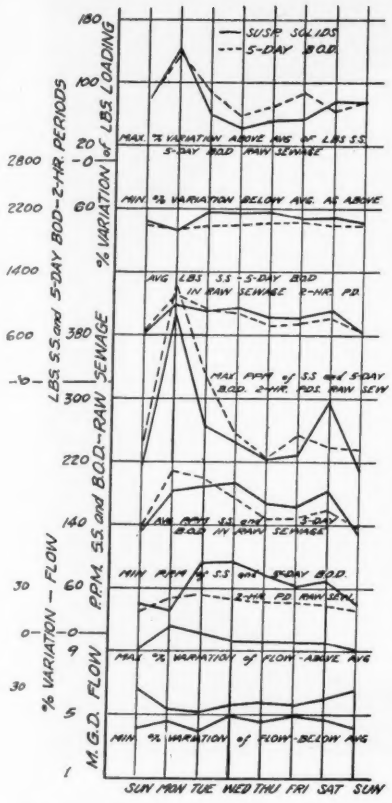
SUSP. SOLIDS
5-DAY B.O.D.
% VARIATION of LBS LOADING
LBS S.S. and 5-DAY BOD-2-HR. PERIODS
MAX. % VARIATION ABOVE AVG. OF LBS S.S. 5-DAY BOD RAW SEWAGE
MIN. % VARIATION BELOW AVG. AS ABOVE
AVG. LBS S.S. 5-DAY BOD IN RAW SEWAGE 2-HR. PD.
MAX. PPM of S.S. and 5-DAY B.O.D. 2-HR. POS. RAW SEW.
AVG. PPM S.S. and 5-DAY B.O.D. IN RAW SEWAGE
MIN. PPM of S.S. and 5-DAY B.O.D.
2-HR. PD. RAW SEW.
PPM S.S. and BOD-RAW SEWAGE
% VARIATION - FLOW
MAX. % VARIATION of FLOW - ABOVE AVG
MIN. % VARIATION of FLOW - BELOW AVG
M.G.D. FLOW
SUN MON TUE WED THU FRI SAT SUN

FIGURE 2.—Summary of curves illustrating flow and load variations by 2-hr. periods.

displayed by these curves the following are commented upon.

The Sunday flow and load characteristics are in interesting contrast to the Monday flow and load, as was to be expected. The remaining days of the week vary but little from each other.

The point of low flow for Sunday shows a lag of about 2 hours and occurs at 8 A.M., whereas on all the rest of the days the minimum flow point occurs at 6 A.M. The maximum and minimum variation in the flow for Sunday is but 13 per cent above and below the average while the variation in the sewage load carried is 80 per cent on either side of the average.

It is also interesting to note that the hour of minimum flow for Aurora is about the same as that for several cities, such as Columbus, Minneapolis, Indianapolis, Toledo, Baltimore and doubtless many others.

In contrast to Sunday, the Monday flow varies 28 per cent above and below the average, and the sewage load, as measured by suspended solids and B.O.D., varies from 84 per cent below average to 164 per cent above average.

During the remaining days of the week the flow varies from about 20 per cent below the average to 25 per cent or more above average. The sewage load varies from about 80 per cent below average to some 60 per cent above the average.

Generally the flow tends to level off upon reaching its crest and remains fairly constant from 12 noon to 4 P.M. before it tends to fall off for all the days of the week except Sunday, when the crest arrives 2 hours later.

In contrast to the flow, the sewage load has a sharp peak and tends to be at a maximum at about 2 P.M. after which it falls off sharply.

Two other interesting features revealed herein, not anticipated when this study was started, were that the loading due to suspended solids is very nearly equal to the loading represented by the B.O.D. The suspended solids for the 7 days studied averaged 174 p.p.m. and the B.O.D. 168 p.p.m., or 3 per cent less. This finding differs from the average values reported from the Aurora plant records of the past 14 years, in which the suspended solids averaged 166 p.p.m. and the B.O.D. 122 p.p.m., or 26 per cent less. This variation is probably due to the difference between the more concentrated sewage sampled on the selected dry weather days studied as compared to the general average sewage which includes diluted storm flows.

The second striking feature revealed by these curves is the almost complete

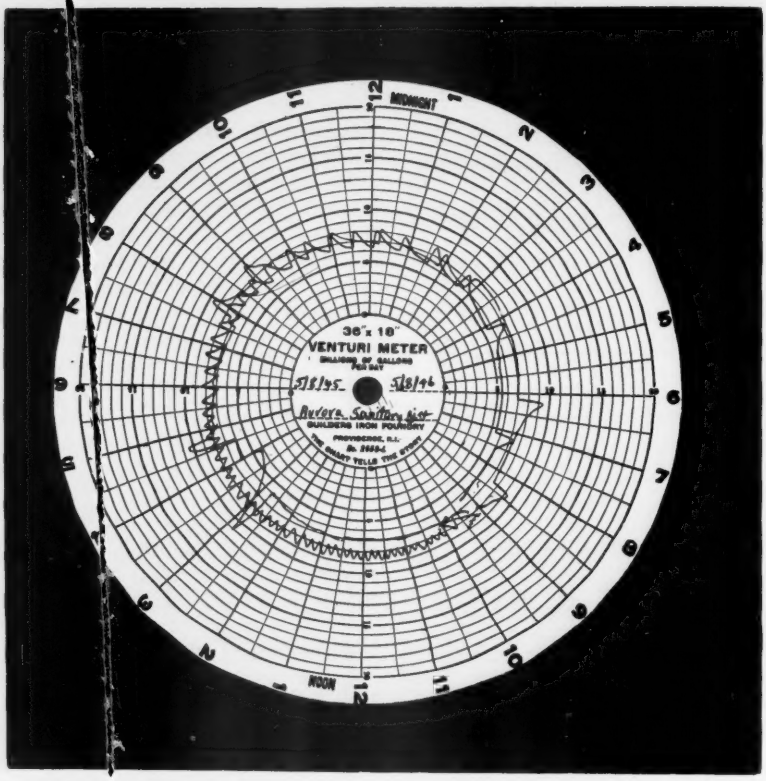

FIGURE 3.—Typical venturi chart recording sewage flow.

parallel relationship between the flow and the loading curves, *i.e.*, the load tends to come and go precisely as the flow increases and decreases.

Figure 3 presents an interesting corollary to Figures 1 and 2, being a typical venturi chart which records the flow to the plant as modified by the operation of the fine screen through which the sewage first passes. The toothed character of the venturi record is the result of the damming effect produced by accumulating screenings and their removal by the automatic rake. During that part of the day when the flow is high and the loading heavy this unloading is considerably more frequent, than the period after midnight when the load is greatly reduced.

"Standard Methods" procedures were generally followed with the exception that the 2-day B.O.D. incubation tests were used in place of the 5-day. This variation from standard practice was necessary because of the incubator space available and the time element.

In order to test the reliability of the work the following tests were applied:

(1) A series of ten Sunday, Tuesday and Thursday samples set up for comparative 2-day and 5-day B.O.D. incubation tests gave the following results:

	2-day B.O.D.	5-day B.O.D.
10 Sundays averaged	120 p.p.m.	131 p.p.m.
10 Tuesdays averaged	195 p.p.m.	183 p.p.m.
10 Thursdays averaged	153 p.p.m.	141 p.p.m.
Average	156 p.p.m.	152 p.p.m.

(2) A study of the suspended solids for all the days tested was made, comparing the suspended solids for each day as determined in the regular 24-hr. composited plant sample with the suspended solids for the same day as derived from the average of the twelve 2-hr. samples collected. Result: average suspended solids from the composited sample 190 p.p.m.; suspended solids from the average of the twelve samples 174 p.p.m.; difference 8.4 per cent.

(3) Spot tests on suspended solids by two workers gave an average of 342 p.p.m. as against 343 p.p.m. on a strong sewage for ten trials, and 163 p.p.m. as against 157 p.p.m. for a medium sewage.

(4) Spot tests for B.O.D. by three workers for ten trials gave an average of 251 p.p.m., 263 p.p.m. and 270 p.p.m. for a strong sewage, and 136 p.p.m. and 156 p.p.m. for a medium sewage as determined by two workers only.

A STUDY OF THE EFFECT OF NICKEL ON SLUDGE DIGESTION *

By W. J. Wischmeyer and J. T. Chapman

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This is a brief report of the methods used and the results obtained in experiments to determine the toxic effect of various concentrations of nickel or nickel salts on sewage sludge digestion. The experiments were made by means of model-size digesters under carefully controlled conditions, in the sanitary engineering laboratory at Case Institute of Technology, Cleveland, Ohio.

In the present search for accurate material on the pollution effects of various industrial wastes, and particularly wastes from the metals and plating industries, there is less to be found in the literature on the subject of nickel than on other heavy metals such as chromium and copper. Yet nickel wastes are encountered frequently in plating wastes and, in many cases, are discharged directly into public sewer systems for treatment and disposal with domestic sewage. Therefore the question of the toxicity of nickel wastes will need to be established for the mutual information of certain industries and public authorities.

Very little experimental work has been done on nickel wastes. It has been assumed that since it is a heavy metal, such as chromium and copper, it too would have a toxic or inhibitive effect on biological action. However, Spencer (1), in a survey of plating wastes in a small plant in England, has found that nickel plating wastes entering the sewage treatment plant over a period of ten years caused no ill effects on the biological action of the trickling filters. This does not show that no inhibitive effects were present, but that none were noticed over a period of ten years.

Barnes and Braidech (2) made experimental determinations of the effect of metallic ions on the digestion of sewage sludge. Among other metal ions they reported a retardation of normal digestion in the amount of 9.4 per cent when 500 p.p.m. Ni^{++} was present and 8.0 per cent retardation when 200 p.p.m. Ni^{++} was present. Snook (3) also reported retardation of normal sludge digestion by nickel with values closely related to those given by Barnes and Braidech. As a result of a close examination of the tables in the Snook report, it was found that there was acceleration of gas production due to the presence of nickel ions. This would seem to contradict the conclusion by Snook that nickel had a "poisoning effect" on sludge digestion.

Procedure

The overall performance of the digestion process is most satisfactorily measured in terms of (1) the volume and composition of the gases produced, and (2) the per cent reduction of volatile solids. Therefore the method of attack of the problem was to inoculate mixtures of fresh and digested solids with different concentrations of nickel, determining the volatile solids content of the various samples before and after digestion, and measuring the amount of gas produced by each sample during the digestion period.

The same procedure was followed

* Material based on thesis presented as partial requirement for the degree of Master of Science in Civil Engineering, Case Institute of Technology, June, 1947.

for each of three tests. The sludge samples were obtained from the Westerly sewage treatment plant, Cleveland, Ohio, and were made up of approximately one part fresh solids and one part digested solids. This mixture was used because it proved suitable for the apparatus used. A 20-day digestion period at a temperature of 90° F. was used throughout the tests.

Fresh and digested solids were obtained and well-mixed in a 10-gal. drum. One-gallon samples were drawn into digester bottles and inoculated with the desired concentration of nickel. Nickel ammonium sulfate was used for the first test and nickel sulfate was used for the second and third tests. The samples were again well-mixed to ensure even distribution of the nickel salt. The bottles were then placed in the water baths and allowed to come up to temperature before being stoppered and the gas collected. This usually took from 8 to 10 hours. Gas volumes were recorded as often as demanded according to the gas production; temperature readings were recorded along with the gas volumes; and analysis of the gas was made once a day to determine the percentage of carbon dioxide. Volatile solids and hydrogen ion concentration (pH)of each sample were measured before and after digestion as a further guide to the degree of digestion.

Apparatus

The apparatus for this study was a twin unit made to permit simultaneous digestion of eight sludge samples under definite and controlled conditions of temperature, and was equipped with suitable means for the collection and measurement of the gases produced.

The unit consisted of eight 2-gal. bottles. Two circular metal tanks were used as water baths, and each tank was fitted to hold and support four of the digestion bottles and the surrounding water which served as the direct heating medium. Each digester bottle was cradled in position and supported from the water bath bottom for free circulation of the heated water, and was fitted with a two-hole rubber stopper; one hole serving as the inlet and outlet for sludge, and the other hole being the outlet for the tubing leading to the gas collecting tube which measured the progress of digestion.

The gas collecting tubes were composed of 5-ft. lengths of 2-in. pyrex glass tubing mounted in a wooden frame for support. They were fitted with rigid rubber stoppers which were taped firmly into the tubing at both ends. At the top, the tubes were fitted with a glass "T" and clamps, which connected the collector tube to the individual digester and also permitted sampling of the digester gas. The bottom stoppers were bored with holes to connect the tube with a levelling bottle to equalize the pressure in the tubes to atmospheric conditions. The tubes were calibrated at 100-ml. intervals, the intervals being divided equally into 25-ml. portions. The total holding capacity of each tube was 2,000 ml. The confining liquid in the tubes was composed of a 20 per cent Na_2SO_4 and 3 per cent H_2SO_4 solution containing methyl orange indicator.

The water bath surrounding the digester bottles was equipped with immersion heaters coiled on the wooden framework supporting the bottles at the bottom of the tanks. The conducting leads terminated in insulated binding posts attached to the side wall of the metal tank. The temperature was controlled at $90° \pm 1°$ F. by means of a bimetal thermoregulator and a supersensitive relay which controlled the current for the heating elements and small circulating pump. Circulation and mixing action of the heating water was provided by a midget fan-cooled continuous duty centrifugal pump, de-

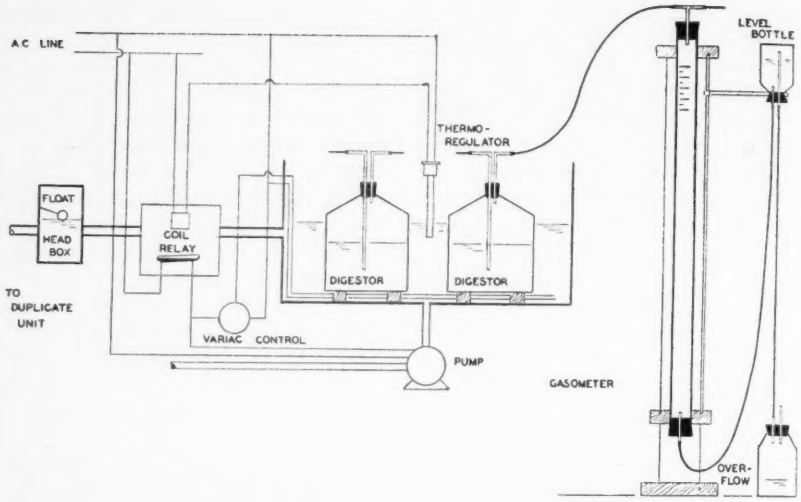

FIGURE 1.—Diagram of experimental apparatus used in studies of toxicity of nickel.

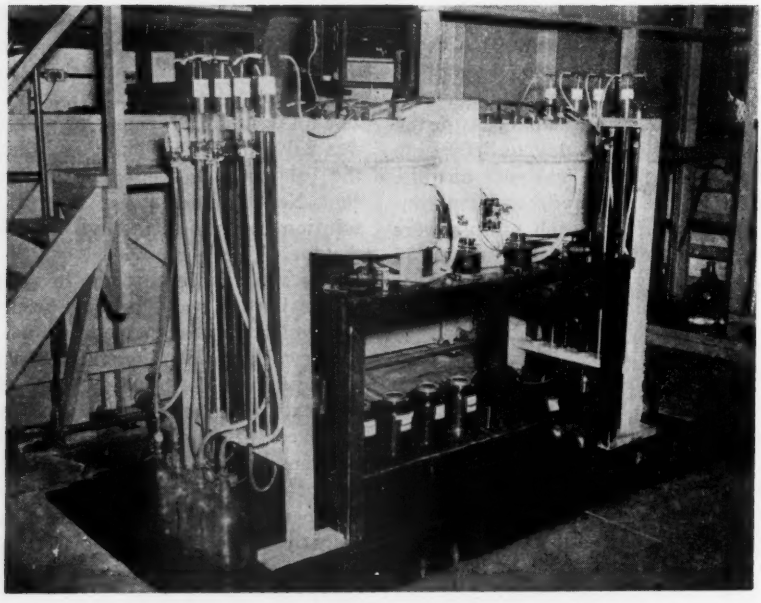

FIGURE 2.—View of experimental apparatus in use.

livering 5 g.p.m. Water was drawn from the bottom of one tank and pumped into the top of the other. The tanks were interconnected by a float operated constant head box. Make up water was added periodically to restore the loss due to evaporation. Figures 1 and 2 show the arrangement of the complete apparatus.

Results

The first complete test of 20-day duration was run using concentrations of nickel ranging from 0 p.p.m. to 133 p.p.m. of $NiSO_4(NH_4)_2SO_4 \cdot 6H_2O$ as nickel. The second test was run using concentrations of nickel ranging from 0 p.p.m. to 200 p.p.m. $NiSO_4 \cdot 6H_2O$ as nickel. For the third test, concentra-

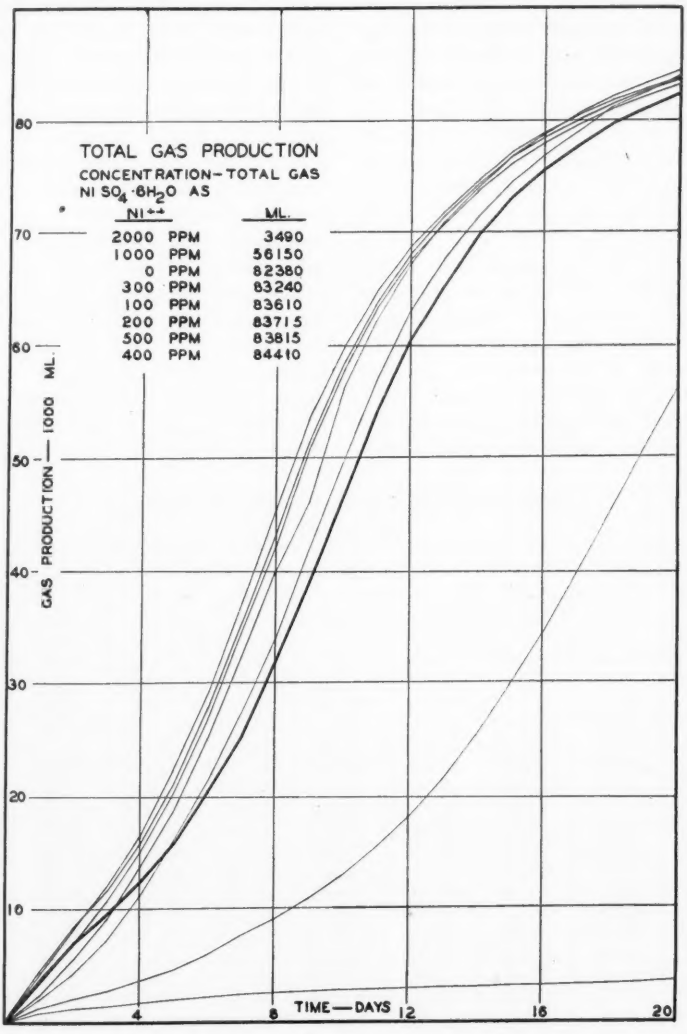

FIGURE 3.—Cumulative gas production from digestion of sludge inoculated with nickel salts.

tions ranging from 0 p.p.m. to 2,000 p.p.m., $NiSO_4 \cdot 6H_2O$ as nickel were used. In each test the sample containing 0 p.p.m. nickel was used as the control.

The results obtained from the three tests followed the same general pattern. Since the third test gave a wider range of concentrations for comparison and was used as a check on the other tests, it will be described in detail. The tests here reported showed no retardation of normal sludge digestion except in concentrations of nickel in excess of 500 p.p.m. In fact, the cumulative gas production curves of all concentrations below 500 p.p.m. were above the curve of the control sample, as can be seen in Figure 3 and Table I. The results indicate that there was a slight increase in gas production due to the presence of nickel up to and including a concentration of 500 p.p.m. The sample containing 1,000 p.p.m. nickel showed a time lag in reaching a high rate of gas production. This lag caused a marked decrease in production over the 20-day period. The sample containing 2,000 p.p.m. nickel produced a negligible amount of gas.

The composition of the gas produced by all samples in each of the three tests, with the exception of the sample containing a concentration of 2,000 p.p.m. nickel, did not vary greatly from what would be normally expected of typical sludge digestion gas. In the first and third tests, the CO_2 content varied from about 50 per cent in the initial stages of digestion to about 20 per cent in the final stages. In the second test the CO_2 content did not vary greatly from about 30 per cent during the entire digestion period. The one exception noted, the sample containing 2,000 p.p.m. nickel, showed an inconstant variation of CO_2 throughout the period.

The tests for per cent volatile solids reduction showed that the varying of the nickel concentration does not cause a like variation in volatile solids reduction, except in the sample containing 2,000 p.p.m. nickel. In this instance, the test for volatile solids re-

TABLE I.—Cumulative Gas Production in Milliliters (Test Run No. 3)

Day	Dosage $NiSO_4 \cdot 6H_2O$ as Ni^{++} (p.p.m.)							
	0	100	200	300	400	500	1,000	2,000
1	3,695	4,510	4,085	3,050	2,435	2,070	1,280	855
2	6,83[illegible]	8,295	8,115	6,880	5,550	4,245	2,070	1,190
3	9,50[illegible]	11,680	12,095	10,745	9,290	7,275	2,790	1,400
4	12,45[illegible]	15,740	16,545	15,125	13,900	11,265	3,680	1,710
5	15,82[illegible]	21,000	22,255	20,225	18,810	15,915	4,630	2,005
6	20,40[illegible]	27,870	29,055	26,885	25,085	21,210	5,980	2,205
7	25,95[illegible]	35,450	37,180	34,455	32,355	27,360	7,645	2,435
8	31,845	43,195	45,275	42,320	39,915	33,870	9,030	2,515
9	38,980	51,440	53,435	50,740	45,900	41,900	10,855	2,625
10	46,600	58,345	59,835	57,765	56,045	49,685	12,980	2,735
11	54,025	63,915	64,890	63,410	62,435	56,975	15,405	2,785
12	60,415	68,180	68,800	67,685	67,270	63,080	18,250	2,885
13	65,325	71,455	71,860	70,910	70,910	67,665	21,435	2,960
14	69,650	74,340	74,625	73,795	74,080	71,485	25,500	3,020
15	73,020	76,660	76,865	76,100	76,680	74,465	29,900	3,070
16	75,605	78,510	78,665	77,970	78,795	76,915	34,575	3,105
17	77,790	80,095	80,215	79,590	80,595	79,115	39,675	3,230
18	79,730	81,495	81,605	81,040	82,110	81,040	45,225	3,340
19	81,180	82,620	82,715	82,200	83,335	82,540	50,775	3,415
20	82,340	83,610	83,715	83,240	84,410	83,815	56,150	3,490

duction showed that digestion in that sample was greatly reduced.

The hydrogen ion concentation of all three tests before and after digestion showed that all samples, except for the one containing 2,000 p.p.m. nickel, behaved in like manner. The pH values increased from about 6.5 to about 7.1 over the digestion period. The sample mentioned showed a reduction in pH value from 6.5 to 5.9.

One other exception was noted during the test using nickel ammonium sulfate. The gas production of all samples inoculated with this salt showed a great increase over the gas production of the control sample, whereas in the tests using nickel sulfate the gas production of all samples with concentrations under 500 p.p.m. nickel was only slightly higher than that of the control. This substantiates the finding of Buswell (4) who states with reference to a certain type of gas producing bacteria in sludge, "These organisms, in addition to producing methane, also possess the following common characteristics: . . . They are obligate anaerobes and are capable of using ammonia as a source of nitrogen."

Conclusion

The results of this study strongly indicate that concentrations of nickel sulfate and nickel ammonium sulfate up to and including 500 p.p.m. as nickel do not retard normal sludge digestion, but rather tend to increase the activity resulting in slightly greater gas production. In concentrations of nickel in excess of 500 p.p.m., and especially in excess of 1,000 p.p.m., the digestion processes are definitely retarded.

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CARBIDE LIME SLURRY FOR SLUDGE CONDITIONING *

By Harold M. Leonhard

Chemist, Wayne County Sewage Disposal System, Wyandotte, Mich.

In May, 1942, a new plant for production of acetylene gas was placed in operation at Wyandotte, Michigan. A pond was constructed in the limited space available for the disposal of the lime slurry waste from this industry but the large volume of slurry produced soon created a problem. Shortly thereafter a representative of the company visited the Wyandotte sewage treatment plant to suggest use of the lime waste for conditioning sludge prior to vacuum filtration.

It was stated that the lime would be made available as a slurry containing about 3 lb. of solids as calcium hydroxide per gallon, and having an average calcium oxide content of about 70 per cent. Further, it was assured that the limestone from which the carbide was manufactured was a high calcium stone of at least 97 per cent calcium carbonate and relatively free from such impurities as magnesium, silica and iron. In the manufacture of calcium carbide a high grade coke is utilized having a low ash content and low ignition point and, upon being charged into an electric arc resistance furnace with the quick lime, it is completely burned due to the high temperature maintained in the furnace. The acetylene gas is produced by wet generation of the carbide with water, and the resulting lime slurry is concentrated by means of a Dorr thickener prior to being pumped to the pond for disposal.

Available Lime Sources

The facilities for the use of lime at the Wyandotte plant at that time consisted of two 20-ton dry lime storage tanks, a conveyor from a hopper under the driveway, an Omega lime feeder and slaker, and two small electric sump pumps for delivering the milk of lime to the sludge conditioning tanks.

Conversion to facilities for handling the waste lime slurry would necessitate the installation of a sizeable liquid storage tank with agitating mechanism, and would require revamping of the feeding system. Hauling the slurry would present no problem since a fleet of tank trucks is maintained for transporting liquid sludge from outlying plants for dewatering and incineration at Wyandotte.

As so often happens the matter was given little study and the use of pebble lime was continued. This was in spite of the fact that considerable difficulty had always been encountered in securing satisfactory pebble lime. When the Wyandotte plant was placed in operation in 1939 there was a local supply of pebble lime available. The lime furnished was of rather poor quality, but since it was delivered by truck directly into the conveyor hopper its use was continued for a considerable period. Finally this local company discontinued operations.

Lime was then ordered from other sources by rail, requiring unloading on the nearest siding into trucks. It was ordered first in bulk in box cars, then in covered gondolas, and finally in paper sacks. The latter was the most satisfactory except for cost. The bulk

* Presented at 22nd Annual Conference, Michigan Sewage Works Assn.; Jackson, Mich.; May 14, 1947.

shipments were difficult to handle and on several occasions employees were severely burned by the lime dust. After several months a new source of lime became available about 100 miles from Wyandotte. A contract was made with a trucking concern for delivery in a semi-trailer hauling 14 tons per trip. This source of lime was very satisfactory until notice was given in August, 1944 that this plant was to be abandoned. A contract was in force for the furnishing of all lime requirements through April, 1945, however, and the company agreed to fulfill the contract by supplying lime from other sources.

From October, 1939 to August, 1944 the price of pebble lime had increased from $8.30 to $10.43 per ton. This fact, together with the prospect of having again to unload the lime from cars, resulted in further study of the possibility of using the carbide lime slurry.

Plant Changes

Arrangements were made to secure a 1,400-gal. load of the slurry. This was fed to the sludge conditioning tanks practically by hand. There being no change in the filter operations nor in filter cake production, a second and third load was fed in a similar manner, after which it appeared certain that the use of this lime waste would be practicable.

Wartime priorities were then in full force. It was decided, however, to proceed with plans for the installation on the basis of unavailability of pebble lime. Plans were prepared, priorities obtained, orders for equipment placed and miscellaneous items such as pipe, valves, fittings, and wiring were assembled. By July 1, 1945 all items of equipment had been received and completely installed.

The installation consists of the following: (1) a covered steel storage tank 13 ft. in diameter with a capacity of 10,000 gal. (Figure 1), located in the basement, (2) a 6-in. filler pipe from a shallow manhole located in the driveway, (3) an agitating mechanism with a 10-h.p. motor direct connected to a gear reduction unit mounted on a bridge over the tank, driving a 48-in. impeller which is suspended 3 in. above the bottom of the tank on a 3½-in. vertical shaft, (4) two horizontal centrifugal pumps, each rated at 12.5 g.p.m., especially designed for handling gritty liquids, (5) a weir box (Figure 2) mounted over the sludge conditioning tank, with an adjustable overflow for returning excess lime slurry to the storage tank. The total cost for all equipment, materials and outside labor amounted to $2,765. All work except welding of the tank and electrical wiring was performed by plant personnel.

During the first week of July, 1945, the use of lime slurry was started and, with the exception of a two-week strike period at the carbide plant, its use has since been continuous.

Operation Procedure

The lime slurry is purchased for $1.00 per ton on a dry basis, loaded into our truck. Lime content is determined from the weight of a 500-c.c. sample from each load. As mentioned previously, tank trucks are operated for transporting liquid sludge from other plants in the Wayne County system (Figure 3). These same 1,400-gal. trucks are used for the hauling of lime. The hauling distance is less than one mile in round trip, and hauling time averages somewhat less than one hour per load. It might be said that the hauling cost is negligible since this is more or less a "fill-in" duty for the trucks and drivers; however, in the cost data presented herein, hauling costs have been based on a rate of $4.25 per hour for truck and driver.

The lime as received varies in solids content from 2.25 to 3.75 lb. per gallon and typical analyses are within the

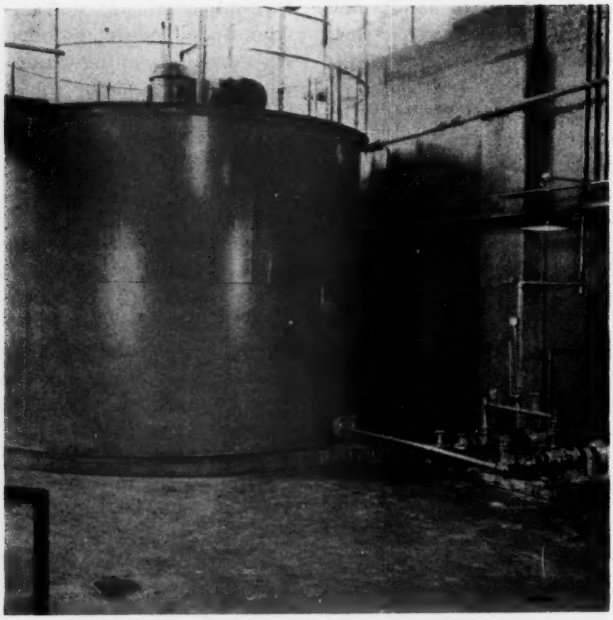

FIGURE 1.—Lime slurry storage tank; pumps at lower right.

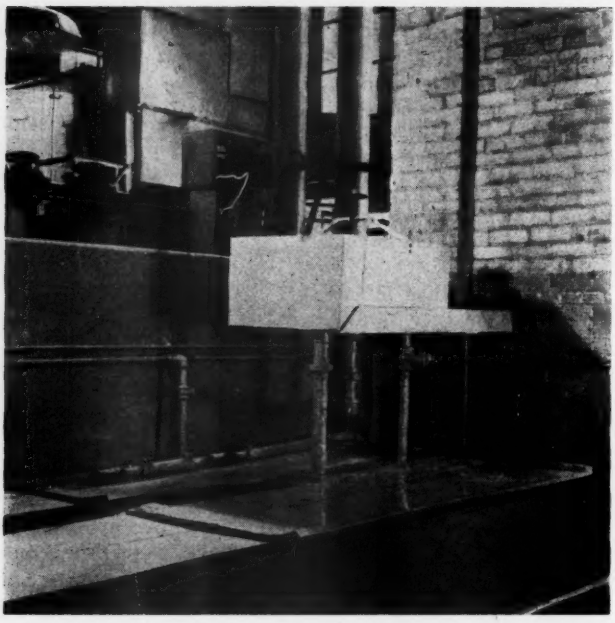

FIGURE 2.—Weir box mounted over sludge conditioning tank for controlling dosage of lime slurry.

FIGURE 3.—Tank trucks used for hauling sludge or lime slurry.

following ranges:

	Per Cent
Calcium as CaO	71 to 75
Silica as SiO_2	0.7 to 2.33
Iron and aluminum as R_2O_3	0.3 to 1.7
Magnesium as MgO	0.1 to 0.5
Carbon dioxide	1 to 2
Combined water	20 to 25

With each load of lime, sufficient water is added to maintain a concentration of 2 lb. of solids as calcium hydroxide per gallon in storage.

The lime feeder pumps deliver the slurry at a uniform rate of about 12.5 g.p.m. to a box mounted above the sludge conditioning tank. A sliding pipe with two notches in the top acts as a return overflow. By adjusting this overflow a constant head is maintained on a small V-notch weir in one end of the box, to feed lime to the sludge conditioning tank at a predetermined rate.

After installation and a short period of operation of the facilities it was necessary to make a few changes. The agitating mechanism was designed for a speed of 82 r.p.m. This caused violent agitation of the liquid and a considerable oscillation of the vertical shaft, so much so that the supporting bridge and power unit would twist and weave. A silent chain drive was installed between the motor and gear unit, reducing the speed of the agitator 50 per cent. This corrected the weaving and still provided sufficient agitation to keep the solids in suspension.

The lime pumps were fitted with water seals on the discharge side of the impeller to protect the packing gland against abrasion. After several hours of operation the volume in storage would increase due to leakage of the seal water into the system. The water seal was disconnected and replaced with a weighted grease cup to feed a small quantity of grease into the gland continuously. It was desired to observe

the effect of the lime solution on the pumps, so rather than alternate the units one pump was kept in continuous service. No repairs other than new packing and minor adjustments were necessary until after 14 months of operation. After this service the impeller and casing were replaced to bring the pump back to capacity. Since then the pumps have been alternated so as to keep them in the same relative condition.

Originally the suction pipe from the storage tank to the lime pumps was 2 in. in diameter. Considerable difficulty was experienced with stoppages in this line, which backflushing with city water pressure often failed to correct. This line was replaced with 1-in. pipe, with a ramrod device operating through a stuffing box for cleanout. This latter arrangement has proved satisfactory.

Costs

Table I shows comparative chemical costs for sludge conditioning for periods of 18 months prior and subsequent to the use of carbide lime slurry.

No attempt has been made to compare life of filter cloths for the two periods since the quality of cloths during and after the war has been so poor and variable that results might be misleading.

The figures given in Table I indicate savings in chemical costs at an annual rate of slightly less than $5,000. In computing costs, no account was made of depreciation or maintenance costs on equipment, since these items would be about the same in either case. The actual cost to date for replacement parts has been $165, including a complete inventory of spare parts for the lime pumps, which might reasonably be expected to need replacement within the next 12 months.

The original equipment for handling pebble lime has been left in place and is maintained in working order, in case at some future date it may be necessary to revert to the use of this type of material. It is hoped that this contingency will never materialize. This hope is shared by all concerned from management to janitors. Aside from the saving in dollars and cents, there are other intangible savings, to wit:

TABLE I

Period	Sewage Solids from Filter Cake (tons)	Filter Yield (lb./sq. ft./hr.)	$FeCl_3$		Lime		Cost of Chemicals	
			Total Pounds	Lb. Per 100 Lb. Solids	Total Pounds	Lb. Per 100 Lb. Solids	Total	Per 100 Lb. of Solids
Jan 1, 1944 to June 30, 1945 (Pebble Lime)	4695	4.32	381,813	4.07	1,709,672	18.20	$16,553.91	$0.176*
July 1, 1945 to Dec. 31, 1946 (Lime Slurry)	4685	4.26	351,220	3.75	1,698,296	18.14	$ 9,078.98	$0.097*

* The costs indicated are based on the following unit prices:

Lime Slurry	Material Cost	$ 1.00
	Hauling Cost	1.32
	Power for Agitation	0.10
	Total	$ 2.42 per ton
Pebble Lime		$10.43 per ton
Ferric Chloride		$40.00 per ton

less attention by operators to the lime handling equipment, no sand or pebbles to be removed from the basement sump, and considerable saving in clean-up labor. No matter how carefully the pebble lime was handled the entire plant would be covered with lime dust after each delivery.

This is not claimed to be the first attempt to use carbide lime for sludge conditioning. At least one other sewage treatment plant in this area has used a waste carbide lime for several years, but in a different form. As far as the writer has been able to determine, however, this is the first installation in this area adapted to the use of the waste lime in the form of a slurry.

It so happens that the Wyandotte plant is ideally located close to the source of this waste lime. It is felt, however, that the material could be transported a considerable distance and still show substantial savings over the use of pebble lime.

It would be interesting, also, to make a study of comparative costs of the lime slurry against hydrated lime in a plant employing chemical precipitation as a method of sewage treatment. In fact, such a study might well be undertaken here, since the Wayne County system includes three small plants where chemical precipitation is used. About the time of the conversion to the use of liquid lime at Wyandotte, however, these small plants were converted to the use of a patented catalyzer in place of hydrated lime. The results obtained and the ease of handling this material, as compared to lime, have at least postponed consideration of other possibilities to some future date.

CARBIDE LIME SLURRY FOR SLUDGE CONDITIONING—A DISCUSSION *

By Fred H. Burley

Engineer of Sewage Treatment, City of Detroit, Mich.

The experience at the Wyandotte sewage treatment plant was of invaluable assistance in leading to the decision to give carbide lime slurry a thorough trial for sludge conditioning at the Detroit plant. All data on the Wyandotte plant work was made available for reference, and opportunity was afforded to observe actual use of the material there.

The use of carbide lime slurry for conditioning of sewage sludge was started on a partial basis at the Detroit sewage treatment plant on November 13, 1946.

Advantages and Disadvantages of Pebble Lime

The Detroit plant as originally designed provided for the use of high grade pebble lime. Some of the favorable aspects of this material with the available equipment were:

1. The dosage required was moderate and capable of reasonably good control. The slakers ran at a constant speed subject to adjustment within the complete range that was desired.
2. The greater part of the pebble lime received was of very high quality and gave little difficulty with accumulations of foreign material in the slakers.
3. The supply and delivery were usually dependable until about 1946.

Some of the unfavorable aspects of the use of the pebble lime at this plant were:

1. The need of hot water for slaking, especially in winter time.
2. The accumulation of deposits of

* Presented at 22nd Annual Conference, Michigan Sewage Works Assn.; Jackson, Mich.; May 14, 1947.

foreign matter in the slakers at times when the highest grade pebble lime was not available.

3. Erratic supply, sometimes necessitating curtailed production.

4. The need of continuous operation of air lifts from the feeding line to the sludge conditioner, due to there being an inadequate head provided between the slakers and conditioners.

5. The recent increase in price.

Conversion to Carbide Lime Slurry

The conversion from pebble to carbide lime has been made step by step, with a minimum outlay for equipment and by running carbide and pebble lime in parallel for observation.

Sources Available

A survey of the Detroit area was made to determine which acetylene plant would be most suited to meet the needs of the Detroit plant. There are certain solidified deposits of the waste material which are approximately 30 per cent solids. On this basis it would be necessary to load and transport daily 30 to 40 tons of the solidified material. On arriving at the plant it would be necessary to provide means of mixing this material with water and conveying it into the plant. It was decided that the cost of labor and new equipment for doing this would be too high.

A number of acetylene producers in the area would be able to supply liquid waste material without storage or thickening equipment at their plants. It was decided that this material would not be economical to transport due to its low solids content. Also, there would be too long a delay in filling tank trucks. The source selected is the same one that supplies the Wyandotte plant, and is located a distance of seven miles from the Detroit sewage treatment plant. The facilities at that source provide thickening and storage equipment. Prompt loading is possible and either tank trucks or railroad tank cars can be accommodated.

A chemical analysis of the material available from this supplier is shown in Table I. As will be noted, the solid anhydrous material is approximately 93 per cent available CaO.

TABLE I.—Chemical Composition of Carbide Lime Slurry

	As Purchased (%)	Converted to Anhydrous Basis (%)
Calcium (as CaO)	72.60	93.30
Silica (as SiO_2)	2.33	2.97
Iron and alumina (as R_2O)	1.29	1.67
Magnesium (as MgO)	0.39	0.50
Carbon dioxide	1.30	1.65
Combined water	22.60	0.00
	100.51	100.09

Transportation

The possibility of leasing railroad tank cars was investigated and the freight rate found to be favorable; however, there were no tank cars available at the time. Consideration was given to the purchase of special equipment, but due to the possible delays in purchasing a heavy tractor and because the availability of the material and its suitability for use in the Detroit sewage treatment plant had not been proven, this investment was postponed. The means of transportation selected and still in use is the employment of a cartage company as a set price per gallon of material hauled.

Equipment at Sewage Plant

In order to provide facilities for delivery of the slurry at the plant a 3-in. hose connection was provided outside the basement of the Chemical Building. This was connected to the suction side of two pumps which were already available as standby equipment for other processes. One of these pumps was a closed impeller, high pressure water pump. It was found to be unsuited for pumping lime slurry

and delivered only about 20 per cent of its rated capacity. The other pump installed was a Chicago "Scru-peller" grease pump. This unit has proven itself entirely suited for the purpose. An additional pump of this type was used to replace the high pressure water pump for this service.

The pebble lime installation at this plant provided four vertical cylindrical storage tanks of 60 tons capacity each. These were investigated structurally and found suitable for the storage of 12,000 gal. each of carbide lime slurry. It was decided to convert two of the tanks for this usage and retain two tanks with complete appurtenances for pebble lime storage. The Bindicators on the converted tanks were removed and overflow piping provided at the 12,000-gal. level. As compressed air was available for agitation it was decided to give this method a trial instead of purchasing a mechanical agitator.

The Fuller valve was removed from these tanks and a heavy plate secured to the bottom flange with a 3-in. connection for removing the lime slurry. The 3-in. slurry line runs to a sediment trap (12 in. in diameter by 18 in. high) where particles of lime scale and clinkers can be deposited. A drain and plug valve are provided at the bottom of this trap. Two 2-in. pipe lines run from the top of this trap to the sludge conditioners. A constant level weir was considered as a feeding device but it was decided to avoid the continuous pumping that would be necessary. Initially orifices were tried as a means to regulate the flow of slurry into the conditioner. These consisted simply of a plate with various sized holes, bolted to the end of a pipe. This was given up due to frequent plugging.

A feeding mechanism which gives valve openings in proportion to bucket elevator revolutions was then devised. This was effected by installing a cam on the ferric chloride Proportioneer shaft. The cam actuates a push rod that opens a quick-acting valve which is returned to its closed position by means of a spring. The quick-acting valves are 1-in. and 1¼-in. standard quick-acting double-disc gate valves. Due to the great number of cycles of opening and closing it has been difficult to maintain the valve packing in good condition. The latest development made along this line is a slide valve spigot of the type used for heavy oils and molasses. This is actuated by a cam and push rod mechanism of the same type described for the quick-acting valves. It has had a fairly short trial but promises to be proving highly satisfactory.

Operation with Carbide Lime Slurry

The method of approach in this conversion was to make a minimum outlay for equipment and material at the start until the economies of the lime slurry were proven. The devices provided initially were fairly crude and there has been a gradual improvement in the piping system and in the methods of control. Tests with orifices showed that under careful control the dosage could be made practically equal to that required with pebble lime. By operating one conditioner and two filters on carbide waste and similar equipment on pebble lime, an excellent comparison was obtainable under conditions as nearly identical as possible.

The deposition of lime on vacuum filter cloths, screens and tubing was found not to be excessive. It has been found necessary to clean the sediment trap and flush the slurry pipe lines on a regular schedule which is routine with each shift. A part of this schedule includes alternating the use of storage tanks.

The original air agitation system was found not entirely successful due to the occasional plugging of the air lines at the bottom of the tanks. Air agitation is now provided by means of a hose inserted at the top of the tank with its outlet weighted and lowered to the

bottom of the tank. This is easily removed for cleaning and has given no difficulty with plugging. A float level indicator has been provided in each tank and observations are made hourly to determine the amount of material used.

Because of the variation in concentration of the slurry as hauled, and the dilution by gland-seal water from the pumps, it is necessary to obtain the CaO content of the slurry as it is delivered to the conditioners. This is done three times during each 8-hour shift. The quantity of slurry delivered to the plant is usually three or four truck-trailer loads daily. The volume of the trailer is 3,400 gallons. The basis of payment for the slurry is the same as that described by Mr. Leonhard for the Wyandotte plant. The transportation cost is paid directly to the cartage company. Converted to a CaO basis the slurry usually contains 2 to 2.5 lb. of CaO per gallon.

Comparison Between Carbide Lime Slurry and Pebble Lime

The dosage can be made approximately equal to that obtained with pebble lime on a CaO basis. This was not achieved on a 24-hour operational schedule at this plant, however, until about March, 1947. The facilities now provided make possible (1) the expeditious unloading of the truck-trailer, (2) pumping only during the unloading period, (3) adequate storage facilities amounting to 24,000 gallons, (4) gravity flow to the conditioners, (5) reasonably accurate control of chemical dosage, (6) relatively small usage of compressed air, (7) no operation of slaker motors, (8) no use of hot water.

The ferric chloride dosage was found to remain relatively unaffected by the kind of lime used.

The life of filter cloths has not been noticeably affected. The average cloth life is approximately 330 hours.

The cost varies with the concentration of the solution. Hauling of water cannot be obviated. The cost on a CaO basis, delivered to the plant, is about half that of pebble lime. Taking other factors into account the cost of chemicals per ton of dry sewage solids is on the average approximately 25

TABLE II.—Comparative Operation Data on Use of Carbide Lime Slurry and Pebble Lime for Sludge Conditioning at Detroit, Mich.

Period	Temp. Sewage (deg. F.)	Mixed Sludge Conditioned[1]				Chemical Dosage, Dry Basis		Per Cent Use of Carbide Lime	Chemicals Cost[2] Per Ton Sewage Solids, Dry Basis ($)		Filter Yield (lb./sq. ft./hr.)
		Raw	Digested	Mixture							
		Per Cent of Total	Per Cent of Total	Solids (%)	Vol. (%)	CaO (%)	$FeCl_3$ (%)		Pebble Lime and $FeCl_3$	Carbide Lime and $FeCl_3$	
Mar., 1946	53	80	20	7.39	61.95	7.60	2.80	0	2.13	—	6.6
Apr., 1946	57	84	16	8.38	66.47	6.80	2.40	0	1.86	—	7.0
Mar., 1947	51	79	21	8.77	61.5	8.08	1.90	70	1.79	1.37	5.0
Apr., 1947	53	81	19	9.10	55.9	8.90	1.80	100	—	1.31	5.5

[1] Approx. bicarbonate alkalinity mixed sludge 1,100 to 1,200 p.p.m.

[2] Cost of chemicals on 1947 basis (delivered to plant):

Ferric chloride—$44.40 per ton
CaO pebble lime—$11.70 per ton CaO
CaO carbide lime—$ 6.50 per ton CaO (March, 1947)
CaO carbide lime—$ 5.70 per ton CaO (April, 1947)

to 40 cents lower with the use of carbide lime.

The use of carbide waste lime slurry has been given a fair trial. The results for comparable months are shown in Table II. The approximate percentages of sludge conditioned by carbide lime during the period November, 1946 to April, 1947 was November—35; December—50; January—35; February—50; March—70; April—100.

It is intended to maintain a supply of pebble lime for standby. This will be run out of the storage bin at times of low carbide slurry supply, or at such time as it should show signs of deteriorating. Otherwise it is intended to utilize the carbide slurry for as nearly 100 per cent of sludge conditioning as possible.

Conclusions

The use of carbide lime waste slurry at the Detroit plant has proved it to be as suitable for sludge conditioning as pebble lime. It has been possible to use the slurry with less power equipment in continuous operation, it is capable of easy handling, and is effecting a decided economy.

EXPERIENCES IN THICKENING AND DRYING OF SLUDGE *

By Thomas R. Komline

President, Komline-Sanderson Engr. Corp., Ridgewood, N. J.

Spray drying of thickened digested sludge with solids content of 12 to 15 per cent has been practiced successfully at Plainfield, N. J. since 1938. The process is simple, rugged and dependable, and would appear to be an ideal method for drying and burning of sludge provided that it would operate on filter cake. There was no opportunity in the past for any experimental work in this direction because (1) the patent situation was clouded, and (2) the Plainfield sludge is not particularly amenable to vacuum filtration.

The first condition was brought about by the fact that the original promoters of the apparatus took out a basic patent on the spray drying of sewage sludge. Their equipment, adapted from the food industry, was not sturdy enough to stand up in daily operation and the operators at the Plainfield plant designed, built and installed machinery that proved satisfactory. The improved machinery stood the test of time, but it was only recently that licensing arrangements were completed so that this type of drier could be offered for use in the sewage works field.

With respect to the filterability of the sludge, a series of tests had been made on a small filter indicating that conditioning could best be carried out with a dosage of 12 to 14 per cent ferric chloride. Lime, or lime and iron in combination, gave a filtrate of poor quality, and there was apparently a tendency for the filter cloth to blind.

Despite potential filtration difficulties the clearing of the patent situation made possible an investigation of the question of spray-drying of filter cake, and permission was obtained from the Plainfield Joint Meeting to conduct a series of experiments over a 6-month period utilizing the existing drier to process the cake.

In addition to the broad question of whether it was feasible to dry filter cake, a number of other points were to be investigated in the course of the program:

1. To examine the practicability of sludge filtration through parallel cords laid in corduroy fashion, rather than through fixed woven cloth.
2. To investigate possible simplification of the conventional system of evacuation of air and filtrate from the vacuum filter.
3. To fix necessary spray bowl speed for proper atomization of the sludge cake, and determine whether peripheral speed rather than rotative speed was the criterion for atomization.
4. To analyze the thermal cycle of the drier to determine whether the burning of the dried sludge would release sufficient heat to dry the wet cake without the use of auxiliary fuel.
5. Perhaps most important of all, to attempt to develop engineering constants and equipment that might be applied to all sludges with confidence.

Cord Filter Studies

A 150 sq. ft. vacuum filter was equipped with the Titeflex-Wright cord attachment, which is composed of a series of rollers, aligning combs

* Presented at Joint Meeting of the New York State Sewage Works Assn. and New England Sewage Works Assn.; Albany, N. Y.; May 26–27, 1947.

and two wash water headers, placed in front of the filter. Braided cord (5/32 in.) is threaded around the rollers and over the drum in corduroy fashion to form the filtering medium, the rollers being so arranged that the cords are washed prior to being returned to the drum. Approximately 17,000 ft. of cord were used in winding the machine, this being shrunk to 13,600 ft. by boiling for one minute as it was being wound on the drum.

In the operation of the filter the scheme of filtration through the interstices of the cords proved to be an immediate success, but some difficulties were encountered in that (1) the aligning combs collected particles of sludge which would occasionally ride through with the cords into the grooved rollers, causing jumping of the cords, and (2) addition of iron as a coagulant resulted in violent foaming of the conditioned sludge, carbonates in the sludge reacting with the iron to form CO_2. After several hours of operation this foam accumulated in the filter vat to the extent that it strangled the flow of conditioned sludge to the filtering media.

The first condition was corrected by better washing of the cords and rearrangement of the aligning combs so that any particles getting past the wash operation would drop off the combs rather than accumulate on them. The foaming condition was alleviated after considerable experimentation by use of a five-bladed agitator which does not actually break up the foam but helps distribute it over the filter so that it does not accumulate in the vat. The foam is picked up along with the conditioned sludge and does not give up any water, but appears as a froth on the surface of the cake.

An interesting development with respect to the disposal of the water used in washing the cords was to divert it directly back into the conditioned sludge, pulling the water out along with the filtrate. An exceptionally clean filtrate is obtained at Plainfield, containing 20 to 30 p.p.m. suspended solids, and this method of handling the wash water obviates any operating difficulty arising from disposal of possibly dirty wash water.

With reference to point two of the program, the problem of evacuation of the filtrate plus entrained air from the filter provided some interesting work. The work was started with the conventional system utilizing separate filtrate pump, vacuum pump, receiver and usual piping, but an investigation of the problem disclosed a style of pump available that would evacuate air, filtrate and wash water in a single operation. Such a unit was purchased and is operating with extreme satisfaction. From a design standpoint the pump is obtainable in capacities to operate efficiently on filters ranging in size from 50 to 400 sq. ft., with power consumption at 0.10 to 0.12 h.p. per sq. ft. of filter surface.

Another point of interest came up in the conditioning and filtration of the sludge. As stated before it was determined that 12 to 14 per cent ferric chloride was necessary for proper conditioning of the sludge over a cloth filter. In contrast to this figure the sludge is now being filtered with an iron dosage of 5 to 6 per cent, at a rate of 7 lb. per sq. ft. per hour. The only present explanation for this phenomenon is that the parallel runs of cord serve to augment or aid the natural drainage property of the sludge, allowing filtration with reduced quantities of coagulant. This point should be checked by work at other plants where comparisons may be made between cord and cloth filters.

Spray-Drier Studies

With reference to the spray-drying of the filter cake the basic problem was to find a way to introduce the material to the spray bowl, and to do this a physical property of filter cake that has been observed in a large number

of plants is utilized. As the sludge leaves the filter in the form of a cake it appears to be stiff and unworkable, but actually when slight pressure is applied the sludge is easily extruded. In practice the cake is pushed through two 6-in. pipes onto the spray bowl, where it is broken up into small particles for rapid evaporation of the remaining water. Approximately 15 h.p. is required to spray a cake of 70 to 75 per cent moisture content at a rate of 1,000 lb. dry solids per hour.

There has been considerable conjecture over the atomizer speed necessary for proper atomization of the sludge. The unit is presently operated at 9,200 r.p.m., and the reliability of the apparatus is attested to by the fact that the original atomizer built in 1938 is still in use, with no spare required, and no repairs needed except to replace bearings every ten to twelve months at a cost of $20. However, if the unit could be operated at 3,500 r.p.m. the frequency changer could be dispensed with, and some work was done at this lower speed, using 60 cycle current. The work indicated that peripheral speed of the spray bowl was the criterion for proper atomization rather than rotative speed, and that satisfactory atomization could be obtained at 3,500 r.p.m. with a 21-in. bowl. The motor horsepower developed at 3,500 r.p.m. was insufficient for continuous operation and the final answer on this point awaits the procurement of a motor delivering 15 h.p. at this lower speed.

Thermal analysis of the drier is relatively simple and foolproof. First, the amount of water to be evaporated per hour is determined. This gives us (1) the size of the spray chamber, (2) the amount of air circulation necessary and size of main circulating fan, and (3) B.t.u. needed for operation of the apparatus. The heat requirement in turn gives the size of the furnace necessary, allowing 1 cu. ft. furnace volume per 15,000 B.t.u. release per hour. Fuel may be dried sludge, oil, coal or gas. If the sludge is to be burned the size of the pulverizing fan is determined from the dry solids handled per hour, and if some or all of the sludge is dried for use as fertilizer base auxiliary fuel burning equipment is chosen to suit local conditions.

To illustrate the above, assume that it is desired to process 1,000 lb. dry solids per hour in the form of filter cake of 72 per cent moisture content. The filter cake will weigh 3,600 lb., of which 2,600 lb. is water to be evaporated (neglecting approximately 125 lb. water remaining in the dried product). This water can be removed in a spray chamber 28 ft. in diameter by 24 ft. in depth, operating at 900° F. inlet temperature and 250° exhaust, with air circulation of approximately 8,500 c.f.m. at 250°. At 60 per cent thermal efficiency it will require $1,800 \times 2,600$ B.t.u. = 4,700,000 B.t.u. per hour input to the furnace to operate the drier. If the dried sludge were to be burned the operation would be in balance if the sludge had a heating value of 5,000 B.t.u. per lb. as fired. This is within range of the usual digested sludge. Furnace size would be 315 cu. ft., and would be $6 \times 6 \times 9$ ft. in dimensions.

With respect to flexibility to meet future growth or unexpected solids loading, the actual design of this unit would call for a furnace possibly 50 per cent larger, and the circulating fan would be belt driven and specified in a size that would permit increasing the air handled up to 15,000 c.f.m. by increasing the motor size and changing the pulley ratio. The spray chamber is adequate to evaporate up to 4,000 lb. water per hour; its minimum diameter being determined by the fact that in a smaller chamber, such as at Plainfield, the spray impinges on the side walls of the chamber, causing some charring and consequent blue haze in the exhaust.

Costs

With reference to operating costs and power requirements, when the unit operates as a drier costs are made up as follows on the basis of processing 1,000 lb. dry solids per hour:

1. Labor at $1.00 per hour	$1.00
2. Power, 30 kw. at 2.5¢	0.75
3. Fuel, $1.00 per million B.t.u.	4.70
4. Maintenance	0.10
	$6.55

When drying and burning the costs become:

1. Labor	$1.00
2. Power, 40 kw. at 2.5¢	1.00
3. Maintenance	0.12
	$2.12

When burning the sludge more power is required because the dried sludge is passed through a pulverizing fan before burning to assure ignition. The maintenance figure is increased to take care of the wear on this unit.

On a dry ton basis these figures become $13.10 for drying alone and $4.24 when burning the sludge as fuel. These figures use high present day costs for labor and fuel, and do not necessarily represent costs for all installations, since more material may be processed by the same labor, and power and fuel may be cheaper in other areas. Power requirements are proportionately less when operating on larger quantities of material.

The same design approach may be applied for larger capacities, in which it may be desirable to increase the size of the spray chamber and place two, three or four atomizers within it, leading separate heat ducts to each atomizer to obtain proper mixing of the sludge droplets and drying gases. This multiple atomizer design affords a large capacity in a single unit building with a reasonable capital investment.

Referring back to costs of conditioning and filtering, up to 60 lb. of ferric chloride is required per 1,000 lb. dry solids, with a total connected load of 20 kw. for metering and mixing sludge and coagulant and driving the filter and vacuum pump. With iron at $200 per ton the cost becomes $6.50 per 1,000 lb. solids, or $13 per dry ton.

Incidental Observations

Before concluding, it is interesting to look back on the work from the standpoint of mistakes that were made along the way.

First, the plunger type sludge pump metering the sludge to the conditioning tank had a positive suction head of 12 ft. total. The effect of this was to permit a portion of the sludge to lift up and then flow past the ball valves, nullifying the metering effect. The solution was to place a sump in the line and arrange the piping so that the pump had to lift the sludge. This sump has been of value in making capacity tests on volume of material handled.

Second, it was found most imperative to keep the sludge moving, both before and after conditioning, to prevent classification and agglomeration.

Third, coagulating chemicals must be constantly and uniformly applied, with provision for screening of coagulant solution to prevent clogging within passages of the proportioning pump.

Fourth, provision for agitation of the sludge within the filter vat should always be provided. The entire subject of filter vat design and piping arrangement for best application of sludge to the filtering medium requires more research.

Fifth, the conditioning tank should be provided with vertical mixing arms, in series, suspended and driven from above the tank, much like the laboratory jar units, to obviate the need of stuffing boxes. The stuffing boxes will always suffer leakage of the water separating from the sludge, causing unnecessary nuisance.

Sixth, with respect to the filter, the original cord was purchased on a competitive basis, and in winding it on the drum defective splices or parts were found in the rope every 150 feet. By a happy coincidence the same style of rope is used in rug mills for power transmission, and fortunately it was possible to secure the services of a mechanic who demonstrated how to make quick, serviceable splices. Specifications for the cord in the future will require less splicing in the field.

Seventh, in future installations the vacuum filter and drier atomizer should be placed on a common operating floor to facilitate operation and cut labor costs. When placed together the two units can be operated by one man in capacities up to 2,000 lb. dry solids per hour.

Conclusion

It is believed that the development work at Plainfield has possibly contributed some answers to the difficult problem of sludge dewatering, drying and incineration that (1) may be applied to a variety of sludges with confidence and assurance that the equipment will operate as planned, and (2) is adaptable for operation by semi-skilled personnel.

The vacuum filtration of sludge is essentially a problem in chemistry and hydraulics. The choice of proper coagulants still remains a local problem, but the consultant now has available a filter in which the media retains a uniform hydraulic condition, allowing for constant solids output. This feature is of definite value in the operation of driers and incinerators.

A simple means for handling of air, filtrate and wash water has been evolved that is applicable to filters up to 400 sq. ft. in size.

Finally, it has been demonstrated that filter cake can be spray dried with the same basic equipment that has proven to be dependable over a period of years in operation on thickened sludge, and constants have been derived that enable this apparatus to be utilized in future plant designs.

REGULATION OF INDUSTRIAL USAGE OF MUNICIPAL SEWERS *

By Clyde L. Palmer

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It is contended in some quarters that there is no justification for controlling the use of sewers in any way, and that the promulgation of sewer use controls is merely an exercise of bureaucratic government for the simple purpose of placing a heavier burden on industry and making life more unpleasant for the innocent. For those who are charged with the responsibility of administering or operating a sewer system and treatment plant serving an industrial community, the need for sewer use control is very apparent. It is believed, however, that an impartial consideration of all the facts would leave few if any points of contention between these two groups.

General Considerations

Modern sewage works are designed principally for the collection, transportation, and treatment of sanitary sewage, for which purpose they are quite satisfactory; they are not designed for or well adapted to the collection and treatment of all of the many and ever-changing waste products of industrial and commercial processes.

It has been contended that municipal sewage works should be designed and built to take any and all industrial wastes in addition to the usual domestic sewage. It will become obvious when examined on the basis of economy that the cost of such a system would be prohibitive as compared to the treatment of certain industrial wastes before introducing them to the sewer system.

For instance, in order to allow acid wastes to be discharged into the sewers untreated, Detroit would be faced with the following problems, which are only two of many that would have to be solved.

Iron pickling wastes are highly acid and, in addition, have a very high chlorine demand as a result of the ferrous iron content. The ordinary chlorine demand of the sewage received at the Detroit plant is in the range of 4 to 6 p.p.m.; however, at certain times and for varying periods, pickling wastes increase the chlorine demand to as much as 100 p.p.m.

If Detroit had to provide facilities for dosing chlorine at a rate of 100 p.p.m. it would mean enlarging the present installation, now said to be the largest in the world, at an estimated additional expenditure in the neighborhood of $2,000,000.

In order to transport these acid wastes through the sewers to the treatment plant, the structures would have to be constructed of acid resisting materials. Detroit has 600 miles of public sewers, ranging in size from 4 ft. to 16 ft. inside diameter. The cost of lining these structures with vitrified tile is estimated to be about $16,000,000.

Although the above described problems no doubt could be solved in several ways, the fact still remains that an entire municipal system would have to be specially built and operated to handle relatively small quantities of damaging material.

In addition to the economic justification for regulation of sewer usage, there are many technical difficulties to be solved in connection with industrial

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waste treatment methods. These problems become increasingly difficult as the proportion of industrial wastes in the total sewage flow increases.

There will probably be no question as to the justification of sewer regulations with reference to those limitations which obviously protect and promote the peace, health, safety, and welfare of the community. Actually, all such regulations are in the final analysis based on this premise.

Assuming that sewers and sewage treatment plants are primarily intended to collect, convey, and treat domestic wastes, it follows then that waste and refuse from industrial processes, insofar as they create an unusual load on the system, constitute a superimposed service for which municipal systems are not designed.

The "Standards and Regulations Controlling the Discharge of Industrial or Commercial Type Wastes into the Detroit Sewer System" are based on the reasoning that industrial wastes that create loads on the sewer system or treatment plant beyond reasonable limits require extraordinary service, for which the municipal system is not designed or obligated to furnish.

As a practical matter consistent with good public policy, it certainly appears reasonable to allow, as a minimum, such industrial wastes to enter the sewer system as would be equivalent to the load and effect of the average sanitary sewage. In addition to this minimum service, it would appear that any further service that could be extended to producers of industrial waste that would not place unusual or damaging loads on the municipal system could be justified, provided no discrimination would result between the different classes of users.

Detroit has designed its sewer ordinance requirements on the above premise, and they are believed to be the maximums of service that can be tolerated in the sewers and treatment plant without damage to the structures, function or process, or without discrimination between classes of users.

The Detroit Ordinance

The Charter of the city of Detroit was conferred under Act 279 of the 1909 Public Acts of the State of Michigan and adopted by the citizens of Detroit on June 25, 1918.

Among other things, it provided that the Common Council's legislative duties include the enactment of ordinances to put into effect and make operative the provisions of the Charter to promote the peace, health, safety, and welfare of the city.

The Charter also provided for a Commissioner of Public Works, authorized to construct and maintain all sewers and to have charge of the disposal of sewage, and a City Engineer under the supervision of the Commissioner of Public Works to have charge of all civil engineering for the department.

On the basis of the above statute and legislation, the Common Council has adopted an ordinance prohibiting the discharge or depositing of "deleterious" substances into the sewers of the city. The regulations defining such "deleterious" substances have been presented in a previous paper (1).

Administration of Regulations

In implementing the control program, it was not found necessary for the city to activate any new administrative bureau, as there were already in existence several agencies whose activities were closely allied to the problem and could be adapted to the new function. The entire program is under the direction of the City Engineer's office.

The City Engineer's Sanitary Design Division receives all reports and follows the progress of abatement through the various agencies involved until the abatement is completed. It may also initiate action to recover cost

of any damage that may have resulted from a violation. The division also takes the initial steps in investigations to discover violations.

The City Engineer's Inspection Division, through its Sewer Safety Crew, makes all field investigations and tests, and reports to the design division and the agency having jurisdiction.

The Fire Department investigates all reports referred to it where flammable liquids or explosive gases are involved, and takes the necessary steps to abate a violation.

The Department of Buildings and Safety Engineering, Plumbing Division, investigates all reports referred to it where a "deleterious" substance is being discharged to the sewers from private property, and takes necessary steps to abate a violation.

The Sewer Maintenance Division investigates all reports of damage to sewer structures referred to it, and repairs the damage after the abatement has been accomplished.

The Health Department investigates all reports referred to it where a hazard to public health is involved, and takes necessary steps to abate violations.

Laboratory facilities are available for the use of the agencies involved in the program at the sewage treatment plant and in the Department of Buildings and Safety Engineering; also, the Inspection Division makes use of a commercial laboratory when necessary.

Experience with Regulations

Although Detroit has had the basic elements needed for controlling the use of its sewer system, these had not been coordinated into a definite program until late in 1946. Previous to that time, sewer regulation was on a complaint basis.

Complaints from private sources still result in the making of numerous investigations; however, the most effective results have been obtained by means of either the routine inspection of sewers carried on by the Sewer Safety Crew as a part of the control program, or by the investigations directed from the City Engineer's Sanitary Design Division and conducted as industry-wide surveys of suspected processes.

The Detroit program has been in operation but a very short time; thus the results that have been accomplished seem small when considering the magnitude of the work yet to be undertaken.

As could be expected, some administrative problems have arisen. Although the facilities of well-established agencies were employed in implementing the control program, the activity was in a new field and equipment and personnel had to be adjusted to the new procedures. This problem is being met and will soon be eliminated.

Because of the need for training personnel and also to establish sound legal precedent, it has been decided to concentrate all of the control activities on those parts of the standards and regulations where damage resulting from violations could easily be demonstrated in the event that legal action was necessary. As a result of this decision, almost all of the activities of the control program to date have been devoted to the abatement of violations involving the discharge of acids, oils, and explosive gases into the sewer system.

Since the start of the program, seventeen cases have been under investigation where strongly acid wastes were being discharged to the sewers, and of this number, compliance has been obtained in all but one case. In the sixteen cases where abatement was accomplished, four had to be taken to court and the record is now being prepared against the one case that has not as yet complied with a notice of violation. The case that is now being prepared involves a condition where tests indicated a strong acid discharge,

but actual damage has not yet occurred. For that reason particular care is being taken to substantiate the evidence thoroughly before legal action is entered.

Four oil refineries located in one sewer district have been under investigation as a result of numerous complaints from residents of the area, and also because of the hazard caused at the sewage pumping station serving the particular system to which the refineries are connected. Abatement in this case has been hindered somewhat by the difficulty in solving the refineries' problem; however, the case is being handled by the Fire Department, which recently reported that the companies involved have been ordered to install more adequate facilities for intercepting their waste oils and that they are now preparing plans for approval.

Although it is not always the case, explosive gases in sewers usually originate from highly volatile oils that are being wasted to the sewers. Numerous complaints of gas odors are investigated, but very few are found to be in the range of explosive mixtures. In most cases, the characteristic petroleum-like odor of sewage is reported as gas and investigation discloses that generally a defective trap allows the odor to enter the building where it is detected. The importance of investigating all such complaints of gas odors is obvious, although, for the most part, they are not of serious nature.

As an illustration of the effectiveness of a coordinated control program, the Sanitary Design Division reviewed the record of gas odor complaints and found that 27 of them had been received over a period of time from one very small area. The office study indicated that one contributing source should be investigated. A field survey was made, and it was found that the substance (a volatile solvent) causing the complaints was being wasted to the sewer from one particular company. The violation was abated without resort to legal measures and no further complaints have been received from the area.

Conclusions

Although the control program at Detroit has been intentionally directed at three specific classes of violations, numerous inquiries have been received from industry requesting investigations and advice as to whether certain other substances could be wasted to the sewer system without causing damage. In general, the experience to date indicates that, for the most part, industry is willing and ready to cooperate with a reasonable control program, and such resistance as does develop will be converted in time by educational methods, although, in the early stages, the program may have to be supported by legal action.

The problem of maintaining satisfactory operating results after the initial step of providing corrective treatment facilities has been accomplished will grow in importance and magnitude as time goes on and more individual plants are installed and operated. It appears that this function of the control program will become the principal activity after a more or less general acceptance of the controls has been accomplished. To date, not too great a success has been won in the matter of getting consistently good results from the processes that have been installed. It is hoped that through mutual cooperation, and by the use of police powers only as a last resort, the effectiveness of the new facilities can be maintained at satisfactory levels. The necessity for continual vigilance appears inevitable, and should be contemplated in any control program.

Reference

1. Palmer, Clyde L., "Control of Sewer Usage at Detroit, Mich." THIS JOURNAL, **18**, 6, 1127 (November, 1946).

REGULATION OF INDUSTRIAL USAGE OF MUNICIPAL SEWERS—A DISCUSSION

By L. A. Danse

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Mr. Palmer's paper affords a lucid and reasonable basis of understanding regarding the possibilities of utilization of civic service sewer structures by industry in the locality. Industry will doubtless be grateful for this explanation, because it provides many points leading to mutual knowledge, upon which industrial sewer users had expressed uncertainty.

Let it be said that industry, certainly insofar as the rather large group of General Motors divisional organizations are concerned, has no part in, nor sympathy with, the contention that sewer usage should not be controlled. General Motors employees are people of the communities in which their industries are located, and they wish to be good citizens and not to constitute a nuisance in or to the community. General Motors being set up on the basis of an industrial democracy, the Divisions are independent, except in matters of policy, where there is close contact and connection with the Central Office. Being a democracy, General Motors people are not too tolerant of efforts to install bureaucratic controls, but they certainly appreciate and make a sincere effort to sustain democratic efforts to improve community functioning. Thus, the attitude responsible for the inauguration and continuation of the company's Industrial Waste Control Group, whose responsibility and duty it is to gather and distribute information regarding good waste treatment control and to promote compliance with reasonable public regulations.

These things being the case, it was considered a privilege that the Detroit officials charged with the responsibility of setting up sewer controls requested the comments of the Industrial Waste Control Group, while formulating the "Rules and Regulations." Discussion on the proposed regulations was vigorous and was productive of much better mutual understanding between corporation and municipal representatives. We believe these discussions actually resulted in more thorough coverage of the situation by the rules and regulations, so as to eliminate misunderstandings on the part of industrial sewer users. The excellent cooperation of the Detroit city engineers, along the lines of promoting improved mutual understanding with industrial executives, should be a model for all those concerned with setting up sewage collection and treatment systems and with improving regulations for their use.

It is manifestly impossible that any large municipal sewage or drainage system could be constructed so as to take any and all industrial wastes. Many industrial wastes are of such nature that they would be deleterious to the materials of construction commonly used in sewers, or they would be hazardous as regards toxicity to those adjacent to the sewer structures; hazardous because of possible explosion damage in or near the sewer structures, a nuisance from the standpoint of noxious odors, or definitely disturbing or deadly to the activity of the sewage treatment processes. Accordingly, industry will understand that wastes which are deleterious or noxious should be pretreated before discharge into public sewer systems.

The plain statements made by Mr. Palmer regarding chlorine demand and

acid-proof structures will be granted and will be agreed to as illustrating the moderate viewpoint of Detroit officials.

In view of the fact that certain municipalities refuse to accept wastes other than domestic sewage, Detroit is to be congratulated for taking the temperate stand that industrial wastes can be taken up to the point where it becomes a hazard to sewer structures, safety, or treatment process activity.

Obviously, if an industrial plant is located where there is a heavy domestic sewage flow, the wastes from such a factory would be less likely to cause trouble than where the plant is located in a district having a small or moderate flow, and the effluent from the industrial plant would be more strongly felt both by sewer structures and by sewage treatment processes than where there was a heavy flow. These facts and conditions make it mutually beneficial for industrial sewer users voluntarily to discuss with municipal sewer authorities the possibilities inherent in the industrial users passing their plant wastes to the sewer system.

With such a reasonable attitude as that displayed in the formulation of the Detroit municipal ordinance and regulations, industry can feel assured that its interests will be given consideration before regulations are made effective for sewer control. The Detroit regulations have been drawn so as to permit industrial effluents considerably beyond the effect of ordinary sanitary sewage, to an extent limited only by the ability of common sewer structures to sustain, and conventional sewage treatment practice to continue processing without interruption or difficulty. The group of officials who developed these Detroit regulations were "industry conscious," and have developed the regulations so as to give industry every advantage short of one which would involve additional expense to the municipality. The authorities have shown a disposition to assist industry in developing means to mitigate its own difficulties and to eliminate its own perpetration of nuisance to community inhabitants and damage to city property.

No discussion or comment is being made on the Detroit standards and regulations, in view of the General Motors' Industrial Waste Control Group having participated in their formulation. It is the conviction of the Industrial Waste Control Group that these regulations not only were fairly and reasonably drawn, but also they are being fairly and reasonably interpreted and applied.

Industrial Wastes

AN INDUSTRY INITIATES A WASTE CONTROL PROGRAM *

By J. E. Cooper

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The Ford Rouge Plant, located in Dearborn, Mich., is recognized as one of the world's largest industrial plants. Grouped into a single unit covering 1,196 acres are blast furnaces, coke ovens, steel mills, paper mill, glass plant, foundry, and vast buildings arranged to produce parts from pressed metal, forging operations, and finally to assemble them into the well-known Ford products.

A few facts inserted here will illustrate the enormous size of such an industrial city:

1. The buildings have a floor area of 13,875,000 sq. ft. and contain 132 miles of conveyors.
2. There are more than 135 miles of railroad within the Rouge Plant—one of the longest private railroads in the world.
3. One and one-third miles of docks are needed to handle water-borne shipments, including upwards of 850,000 tons of ore and 2,078,000 tons of coal a season.
4. Ten open-hearth furnaces make steel for the rolling mill. Six have a capacity of 180 tons, 3 others 110 tons and one 400 tons.
5. More than 538,000,000 gallons of water are used in one day's operations.

The raw water supply of the Ford Rouge Plant is taken from the Zug Island Channel of the Detroit River, passes through the screen house and then flows by gravity to the Rouge Plant via a 15-ft. tunnel. At the Rouge Plant it is pumped through the main condensers at the No. 1 Power House and then divided; one portion flowing to the high service pumping station and from there distributed for use throughout the plant, and the other portion passing directly down a 12-ft. tailrace tunnel to the Rouge River.

The high pressure water distributed throughout the plant finds its way to the Rouge River through four other major outlets after passing through a myriad of smaller sewers in the plant.

The wastes which are under study and survey are those which are inherent and characteristic in the operation of blast furnaces, coke ovens, steel mills, rolling mills, paper mill, glass plant, electro-plating, foundry, and the many machining operations consuming oil and lubricants. These consist of spent steel pickling acids, ammonia still and final cooler wastes from the coke ovens, metal salts and cyanides from electro-plating, emulsified soluble oils and lubricating oils from machining operations, paper mill fibers and asphalt from board making, iron ore dusts from the blast furnaces, and others.

Since the technical data necessary to determine the proper solution to a waste disposal problem derive from the results of many thousands of separate laboratory determinations of a specialized nature, the Ford Motor

* Presented at 22nd Annual Conference, Michigan Sewage Works Assn.; Jackson, Mich.; May 16, 1947.

Company proceeded to construct a special Water and Wastes Laboratory, fully equipped to handle such a project.

This paper will attempt to describe this laboratory in detail, mentioning functions, methods used, equipment, and a brief description of the major problems encountered thus far in the wastes survey.

Objectives

It is the general overall plan to survey completely all the manufacturing units which comprise the Rouge Plant and determine as completely as possible what waste problems are involved. In a small industry this is a relatively simple matter but in the Ford Motor Company it is one of gigantic proportions and is exceedingly time-consuming.

Bland (1) has indicated that the general procedure for attacking a waste disposal problem is divided in five fairly distinct steps:

(a) Preliminary groundwork to define the specific problem.

(b) General study of the defined problem.

(c) Development of treatment or disposal methods.

(d) Design and construction of equipment.

(e) Test of plant operation and survey of effect on surrounding surface waters.

There are generally two schools of thought on the methods of proceeding in an industry where a multiplicity of wastes occur. Briefly, these might be stated:

(a) Determine all facts relating to one waste product and proceed with installation of treatment plants or measures to eliminate it completely as a problem before proceeding to the next, or

(b) Make a complete and thorough survey of all wastes in the industrial plant and evolve a general plan designed to solve the waste problem by planned progressive measures, taking into consideration all factors such as economy, benefits received, relative importance of various wastes, time involved for scientific research on methods, and many other factors relating to each individual waste material.

In the Ford Rouge Plant the objective has been to follow the second course with the exception that when, in the course of a sanitary survey of a specific waste, it is found that measures can be taken immediately to relieve the problem by a minor change in operating procedures, better maintenance, or stopping of a waste at its source, these measures are put into effect as soon as possible. This results in a progressive pollution abatement program which accompanies the progress of the overall survey.

One of the main considerations for following the second course more closely than the first is the possibility that the chemical or physical characteristics of one waste may be utilized against another. An example might be the use of waste from an acetylene plant to neutralize spent acids from the pickling of steel or the cleaning of parts before plating. The advantages of such a plan are obvious. An industry should receive all possible benefits from utilization of the waste products from its plants rather than hastily construct uneconomical treatment plants which might easily become obsolete as their survey progressed and indicated a simpler but previously unknown or unrecognized method of waste disposal.

Organizational Plan

There are many departments, sections and units of the Ford Motor Company which have an active interest in industrial wastes, and as progress continues many others will be brought in as they become affected. At present there are three main groups which

are actively identified with waste control:

(1) Plant Engineering Department
(2) Chemical and Metallurgical Research Department
(3) Medical Section.

As a matter of interest, a brief statement is included concerning the major interests and responsibilities of each of these groups in the waste control program.

Plant Engineering Department

The Plant Engineering Department is concerned with the interpretation of the waste surveys and the application of corrective measures. This function includes not only construction of necessary treatment facilities, but redesign of existing equipment and processes for the purpose of minimizing losses of wastes to sewers. Field surveys, in close co-operation with laboratory personnel, are made for the purpose of obtaining physical and hydraulic data on the sources, location and quantities of wastes. Economic analyses, such as cost estimates of proposed treatment facilities, and the organization and presentation of projects for review and disposition by the management, are important functions of this department.

Chemical and Metallurgical Research Department

Special analyses and extremely valuable technical assistance are provided to the Water and Wastes Laboratory by this department or by the Chemical Engineering Department. Since the latter operates many separate control laboratories, each attached to a different manufacturing process (*i.e.*, coke-oven laboratory, paper-mill laboratory, strip-mill laboratory, main chemical laboratory), they are in a position to furnish valuable data and assistance relating to the process they serve.

A Chemical Engineering Research Department as a separate group is new, and it may be expected to play an ever-increasing part in the waste disposal program as the survey progresses and points out the problems which must be met by a broad research program.

The Chemical and Metallurgical Research Department provides for co-operative research with the Water and Wastes Laboratory on new, more economical and more efficient methods of wastes disposal and utilization. Proposed treatment facilities are developed and reviewed from the standpoint of efficiency, cost, and how they relate to present chemical engineering processes. Any suggested changes in operation of any chemical process (for the purpose of minimizing wastes produced) are reviewed by this department.

Medical Section

The Medical Section is charged with the responsibility for establishing policies and discharging duties relating to public and industrial health and sanitation. This activity includes, among other things, sanitary control of water supplies, sewage treatment, industrial wastes disposal, stream sanitation, and other activities in the Ford Motor Company which have either a direct or indirect relationship to public health engineering. It provides for the operation of a Water and Wastes Laboratory which carries on the functions outlined above and which operates in a manner directly comparable to the Bureau of Engineering of the Michigan Department of Health, and the Sanitary Engineering Division of the U. S. Public Health Service, that is, a unit of chemists and engineers working under the direction of a medical authority.

Water and Wastes Laboratory

This Water and Wastes Laboratory was constructed under the direction of Dr. H. L. Krieger, Medical Director, Ford Motor Company, during the

Engineering Library

winter and spring of 1946, and now operates under the direct supervision of the Physician-in-Charge, Rouge Plant Hospital, Dr. W. A. Dawson. Organizationally, it is a unit of the Medical Section, Employee Services Department, Industrial Relations Division, of the Ford Motor Company.

The laboratory is under the immediate direction of a Supervisor, who directs the technical activities relating to industrial waste control throughout the company. The Supervisor reports directly to the Physician-in-Charge, Rouge Plant, on all matters relating specifically to that plant, and to the Medical Director on Relations concerning branch plants whether it be in regard to water purification or waste control.

The laboratory performs the following general functions:

1. Directs operation of water purification plants in accordance with Act 98 of Public Acts (Michigan) of 1913. (Requires licensed operator who is in "active operating charge" of all water purification plants.)

2. Makes routine bacteriological analyses and has control of sanitary quality of all water supplies provided to Ford employees and/or is available from the Ford Motor Company to the general public.

3. Provides sanitary control of swimming pools in accordance with state regulations.

4. Directs operation of sewage treatment facilities in the Ford Motor Company.

5. Makes complete chemical, bacteriological, and biological analyses of waste flows and determines the volume and concentration of wastes in the flow.

6. Initiates industrial wastes surveys designed to locate the source, quantity, type, and reason for loss, of any waste materials found in sewers or waste outlets.

7. Initiates research projects in the Water and Wastes Laboratory and cooperative research in the Chemical Engineering Department on more efficient and economical methods of industrial wastes disposal.

8. Coordinates activities of all departments in the Ford Motor Company concerned with the control of the sanitary facilities and provides periodical progress and operating reports to governmental agencies, as required.

9. Represents the Ford Motor Company in "technical relations" with local, state, and Federal agencies mutually concerned with those phases of sanitary engineering and public health which relate to water supply, sewage disposal and industrial wastes in the Ford Motor Company.

The laboratory staff required to carry out the above functions is represented by a supervisor, a secretary, and five technicians, representing training, education, and experience in the fields of chemistry, engineering, and the sanitary sciences, as well as practical operating experience in the operation of water purification, sewage treatment, and industrial waste treatment plants.

The laboratory is located on the ground floor at the front of "B" Building, the main automobile assembly building. It is adjacent to the Rouge Plant Hospital which is located directly above on the second floor.

The equipment is new and modern, with the laboratory benches, center tables, sinks, etc., built in as a unit and constructed entirely of stainless steel. The instruments, equipment, sampling devices, etc., are ample to carry on those physical, chemical, biological, and bacteriological analyses specialized to sanitary chemistry.

Current meters, for hydraulic measurements, portable chemical feeders, pumps, and many other items too numerous to mention, all contribute to form one of the most complete laboratories ever assembled by an individual

company, specifically for the study and control of sanitary problems.

An additional piece of equipment is a complete experimental filter plant (Figure 1) located in the Screen House at the tunnel intake where the mill water supply is taken from the Zug Island channel of the Detroit River. This plant was patterned after the original one designed and built at the Case School of Applied Science in Cleveland, Ohio, under the direction of Prof. G. E. Barnes. It is a complete water purification plant in dual, but lends itself admirably to studies on industrial wastes.

Waste Surveys

The methods used in the survey generally are similar to those followed by the U. S. Public Health Service in the work on the Ohio River (2), but are carried to somewhat more detail and are varied as conditions differ in the plant from those encountered in the industries along the Ohio River.

An attempt is being made by a comprehensive program of sampling and analysis to determine the present sanitary condition of the Rouge River above, adjacent to, and below the Ford Motor Company, by a long-range series of samples which determine B.O.D.,

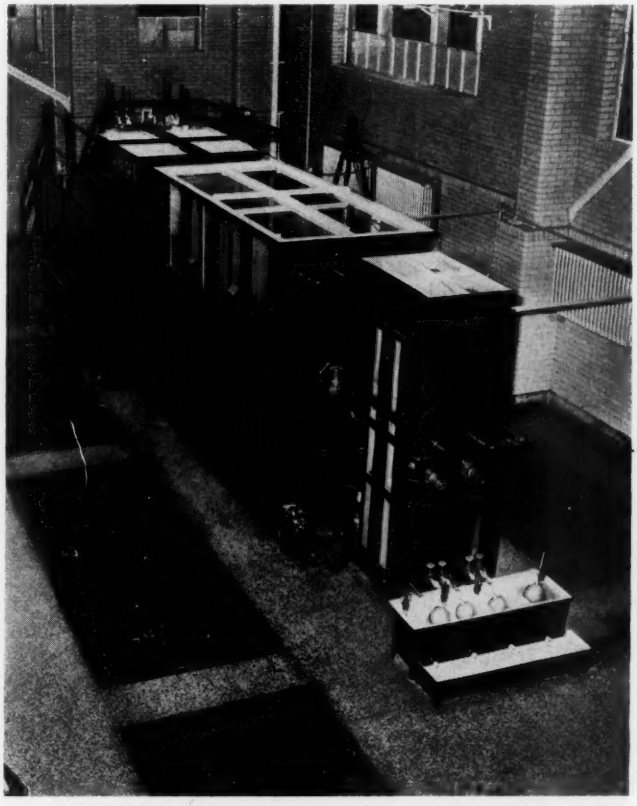

FIGURE 1.—Experimental water filtration plant used for water and industrial wastes studies.

D.O., pH, alkalinity and bacterial content. Results of this survey, it is hoped, will define the effect of the Ford Motor Company on the biochemical characteristics of the Rouge River and provide an index as to what effect various abatement measures will exert on the river.

The major outlets from the Rouge Plant are each being thoroughly studied to determine their contents and individual effects on the river. This work requires elaborate sampling for composite samples representing average conditions, along with concurrent hydraulic measurements of discharge (Figure 2), and subsequent analysis in the laboratory. It might be well to point out that this is a large and important undertaking as the smallest of these outlets will average 28 m.g.d., with the others ranging upward to 200 m.g.d. High velocities, thermal stratification, effect of physical tendencies of oil to rise, and suspended material to settle even in such large flows, all contribute to make sampling for accurate representative composites a very exacting procedure and require many preliminary measurements. Frequent consultations have been held with both state and federal officials on techniques in this connection, and valuable assistance has been received from both groups.

Laboratory procedures for analysis

FIGURE 2.—Waste flow measurements by use of current meter.

of waste products in high dilution and in the presence of many other chemical compounds are carefully examined before use, and the many methods evaluated with respect to these particular conditions. When possible, *Standard Methods for the Examination of Water and Sewage* or other officially recognized methods are used. Too often the analyses required of industrial wastes have not reached the refinement desired or do not fit the conditions under consideration; thus modifications of known methods must be studied and adapted to existing conditions. This is one of the many time-consuming details required in a comprehensive survey.

A particular advantage enjoyed by this laboratory, but not shared by smaller companies, is the abundance of technical specialists throughout the Ford organization, who are available for consultation. Many facilities are available for special types of analyses, such as x-ray diffraction units in the Applied Physics Section, and many hundreds of instruments and techniques, each under the direction of a recognized expert of a special field. An example is cited where a sample of oil was collected from an outlet and its characteristics altered after being in a sewer to the extent that the Water and Wastes Laboratory was unable to identify it or determine its source. A request was made to the Chemical Engineering Department and they promptly identified it as to its "M" number (Ford Motor Company code system for reference to specific compounds) and its source was then ascertained by checking records of department charges for that particular oil in the drainage area served by the outlet.

Research

Some applied research has been and is being carried on relating to new methods of treatment of waste steel pickling liquor, removal of carbonates from plating solutions to obviate the necessity for frequent disposal of concentrated plating baths, treatment of ammonia still wastes from coke-ovens, treatment and control of emulsified soluble oil coolants, chlorination of cyanide wastes, and others. Work is continuing on these projects as rapidly as time and personnel permit. Future indications are that more of the truly research problems will be outlined by the laboratory, along with the facts found during the wastes survey, and the whole project turned over to the Chemical Engineering Research Department to work out the technical phases and develop a satisfactory practical solution.

Reducing Losses

Field survey work and organization to provide better control over the loss or discard of waste materials has been one of the prime endeavors. This type of work is best represented by a recent comprehensive report on oil wastes in the Rouge Plant. Many weeks were required by two staff members from the Water and Wastes Laboratory in determining extent of the problem. In an early meeting with representatives of the Michigan Stream Control Commission, they indicated a preference or an "order of priority" on which the plant wastes should first receive concentrated study. Oil wastes were decided upon, and the resulting survey proved it to be a problem which required a most intensive detailed plant study to determine consumption, use, salvage and ultimate disposition.

Men were assigned to go through accounting records, stock records, cost control records, etc., in an attempt to account for the consumption of all oil used in the Rouge Plant during a given month. Following this, investigators were sent into each building and department in the Rouge Plant to question foremen, machine operators, maintenance men, plumbers, etc., to

FIGURE 3.—Attempt to measure rolling mill wastes entering scale pits, where iron oxide scale is removed by sedimentation.

learn exactly what happened to the oil they consumed and whether or not the consumption could be reduced, or more oil salvaged.

The report of this investigation prompted the Rouge Plant General Manager to detail members of his staff on a special assignment to devise ways and means of better oil control for alleviating oil losses at their source. Much of the progress in the control of industrial wastes in the Rouge Plant is a result of the efforts of this group.

A second thorough study was initiated recently by the Water and Wastes Laboratory on the problem of soluble oil wastes. This survey attempted to determine all factors concerned with this waste such as quantities consumed, reason for becoming spent and possible methods of recovery. Three large continuous purification units, one a filtration system, and two other flotation units, have been installed; two in the Motor Building, and one in the foundry. These units continuously remove chips and grinding particles from the coolant or "soda water" as it is generally referred to by the men in the shop. These units have not been in operation long enough to make a critical evaluation as to their relative efficiency, but they do lengthen the useful life of the "soda water" tremendously. The complete responsibility for the treatment of soluble oils with disinfectants and the disposal of same have recently been transferred to this laboratory and the establishment of the organization required for routine control is now in process.

Other surveys of a detailed nature yet to be made are concerned with obtaining complete data relating to plating wastes, caustic and acid cleaners, and a host of other chemical compounds used generally throughout the Rouge Plant.

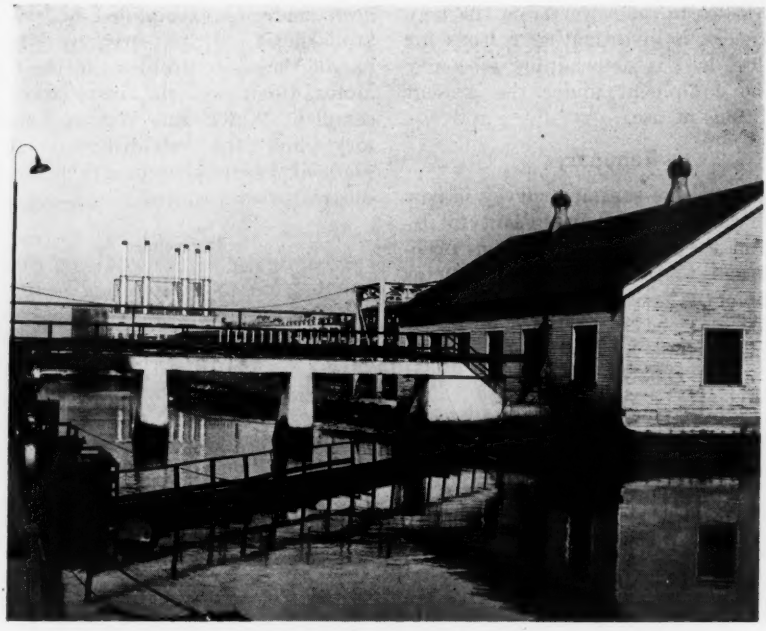

FIGURE 4.—Oil skimming device at head of boat slip for removal of oil from Roulo Creek.

Some of the major outlets, notably that referred to as the "Gate 11 Sewer," have received considerable study as to the average flow and the waste compounds contained. At present an effort is being made to learn the exact source of the waste materials in the drainage area served by this particular sewer, which has an average discharge of 40 m.g.d. Among the contributors are scale pits which are a part of rolling mill operations in the Steel Division. Hydraulic and laboratory determinations are being made on the wastes from these scale pits for the Plant Engineering Department, which will attempt to learn whether the pits can be made more efficient and thus relieve the load of suspended solids in the Gate 11 outlet.

An interesting feature of this work was the determination of the flow of water entering one scale pit (Figure 3). Hydraulic conditions made usual methods of flow measurement ineffectual, although a trapedozoidal weir was installed in an attempt to measure the flow. Too great a slope in the water surface approaching the weir, along with turbulence in the conduit, threw considerable doubt on the accuracy of the weir measurements. As an alternate method of flow measurement, there was installed a small chemical feeder which fed concentrated sulfuric acid to the flow in accurately controlled doses. It was then possible to measure the sulfate increase in the water leaving the scale pit by turbidimetric means. A high degree of accuracy was achieved by this method with a flow which varied, during the 24-hour test run, between 2,000 and 4,000 g.p.m.

Blast furnace wastes have received some attention and the Plant Engineering Department, following receipt of a report from this laboratory on ore

dust losses to the sewer from the tray thickeners, is investigating reasons for the loss and is determining efficiency of the equipment under the present conditions of use.

Summary

An intensive sanitary survey is now underway in the Rouge Plant to determine the extent of the various problems and to reduce as completely as possible the losses of wastes at their source.

Considerable progress has already been made, as exemplified by the establishment of an organization to handle the waste problems in the Ford Motor Company, the installation of complete Water and Wastes Laboratory, and the establishment of a planned progressive program for industrial wastes control.

References

1. *Nat. Pet. News*, **38**, No. 10, 177.
2. "Ohio River Pollution Control" (2 vols.), House Document 266, 78th Congress, 1st Session.

THE INDUSTRIAL WASTE PROBLEM. III. RECENT DEVELOPMENTS IN PULP AND PAPER WASTE TREATMENT AND RESEARCH *

By Harry W. Gehm

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In the past much more attention has been given to the development of pollution reduction methods applying to sulfite waste liquor and machine waters than to other pulp and paper wastes. Since the kraft and soda processes evaporate and burn the pulping liquor for recovery of chemicals and heat, pollution from such mills is negligible as compared to the sulfite process. It has been found, however, that kraft and soda mills located on streams of low summer runoff can cause severe seasonal pollution. It has also been established that certain constituents of such waste waters are toxic to fish if present in the receiving stream at sufficiently high concentration.

Improvement in recovery systems and control of operating irregularities have tended to reduce the pollutional load from such mills to an appreciable degree. Nevertheless, some problems remain, particularly at mills where the pulp is bleached, since the bleachery waste represents an additional oxygen load although its addition to the pulp mill waste does destroy a number of the toxic compounds contained therein.

Storage

Laboratory and pilot plant experiments at mills in Texas and Virginia indicated that high reductions in B.O.D. of these wastes could be obtained if they were sufficiently dilute, and after removal of suspended solids by storage for periods of from 15 to 30 days. In one case it was found that sufficiently high initial dilution could be obtained by inclusion of bleach plant, groundwood mill and machine water. In the other the concentration was reduced by segregation of small volumes of concentrated waste, which was lagooned for controlled discharge during high stream flow. At both of these mills it was decided, on the basis of the experimental work, to install full scale storage basins, and to date one has been in successful operation throughout one summer period.

During the operating period the mill effluent B.O.D. varied between 168 and 260 p.p.m. while the effluent discharged to the river varied between 28 and 56 p.p.m., averaging about 45 p.p.m. This treatment served to prevent severe oxygen depletion in the river throughout the entire summer period, throughout which fish life abounded in the stream. The equalizing effect of the storage basins also served to protect the stream from shock loads resulting from operating irregularities in the mill.

Continuing laboratory research has indicated that the efficiency of this process might be considerably improved. Although substantially anaerobic and attended by sulfate reduction, odor production at the basins has not been nearly as severe as anticipated. This method of treatment is particularly applicable in the South due to the high summer temperatures, abundant waste land generally isolated from communities, the nature of the streams and the concentration

* One of a series of special contributions by members of the FSWA Committee on Industrial Wastes.

there of the kraft pulping division of the industry.

"Sludge-Blanket" Clarifiers

Considerable progress has been made during the last five years in applying the "sludge-blanket" type of clarifier for fiber removal from paper machine waters. Despite periods of upset these devices yielded a high degree of clarification.

Study of the difficulties led to the discovery that variations in temperature, entrained air, flow surges and fluctuations in the solids load all disturbed the suspended slurry blanket. Correction of the three former conditions and improvements in the sludge removal system have corrected troubles to a considerable degree.

The addition of activated silica where alum is employed as a coagulant was found to aid operation since the silica increases the density of the slurry particles, thus rendering the blanket less subject to disturbance. Considerable effort is being directed by manufacturers to improve the sludge collection system in the hope of providing greater thickening of the sludge discharged. Performance of several recent designs will be watched with interest by the industry.

Bleaching Operations

Increased kraft and soda pulp bleaching operations throughout the country have made bleachery waste an increasingly important pollution problem. One of the particularly undesirable characteristics of this waste is its high color due to extracted lignins. Experiments have shown that treatment with lime can effectively remove most of the color.

Since the disposal of sludge produced by such treatment would pose a major problem, the possibility of incorporating the treatment process with the causticizing mud recovery system is being explored. By employing bleachery waste as a scrubbing medium for lime kiln stacks in devices in which it will be treated with lime dust, carbonated and settled, it might be practical to return the sludge to the causticizing mud recovery system, and a part of the clarified effluent to the bleach plant for re-use. Data obtained to date on this process are encouraging.

Aeration

Progress in reducing the high dissolved B.O.D. of the wash water from deinked pulp has been evidenced by the laboratory development of an aeration process capable of obtaining 80 per cent reduction consistently. This process operates at the high pH values (8.0 to 9.5) commonly met with in such wastes and requires a nitrogen supplement of but 10 p.p.m. of sodium nitrate. Pilot plants studies are now proceeding which will serve further to develop and evaluate this process for application.

Sulfite Process Modifications

Changes in base in the sulfite pulping process for the purpose of incorporating liquor burning—hence largely eliminating stream pollution—are receiving great interest in the pulp and paper industry both here and abroad. A full scale plant employing magnesium bisulfite as cooking acid should be in operation this year and extensive experimentation with ammonium bisulfite is underway in lieu of the possibility of future low price ammonia.

In the development of these methods rests the future promise of elimination of pollution from large mills, since permanent markets that can be established for by-products from the liquor are very limited, and treatment processes astronomical in cost. As examples are the facts that but 5 per cent of the liquor produced at present goes into by-products, and treatment plant costs, providing partial B.O.D. reduction only, exceed the value of the pulp mill. If successful the base

change processes, though high in initial cost, are likely to meet acceptance by the large sulfite producers since returns in the form of heat and (in the case of magnesia and sodium) chemicals as well are inherent to these processes.

Since successful adoption of base change to the small sulfite mill is not likely to be feasible, considerable research in fermentation processes is being conducted. In Wisconsin a full scale plant for the production of fodder yeast is being erected which process is expected to reduce the oxygen demand of the liquor to a considerable degree. The economic position of this material in this section of the country will be established by this operation.

Sludge Disposal Problems

One of the major unsolved problems is the dewatering and disposal of sludges removed by sedimentation or chemical coagulation of a number of waste waters produced by this industry. The failure of existing methods to handle these hydrous sludges indicates the need for fundamental research leading to new techniques for the removal of bound water.

Laboratory studies employing electrodialysis and ultrasonics are now being conducted to determine the possibilities of their application to this problem. Extensive investigations and research on recovery of usable materials from such sludges have not proven successful, due to their highly variable composition, cost of recovery, impurities in recovered materials and changes in character brought about by the separation process. Hence the trend is likely to be toward disposal or simple uses such as for fill and road work, when the sludges can be obtained in a workably dry state, rather than for process reuse. Methods for stabilizing such sludges against odorous decomposition during temporary lagooning are now being sought.

Deinking Wastes

The continued world shortage of pulp is rapidly leading to changes in the industry which have a direct bearing on effluent problems. The increased re-use of waste paper and the use of lower grades of waste for deinked stock has increased the pollution from this source. Manufacturers are anxious to retain the material losses subsequent to manufacture in the product, and while at present no means are available for doing this such are being sought. Much of the difficulty here lies in the nature of inks now employed since the pigments released by the deinking process discolor the fillers washed from the pulp and preclude their re-use.

Increased production and process improvements in semi-chemical pulping is an example of greater utilization of raw material in the product and lower sewer losses. New processes from which the pulp yield exceeds 80 per cent of the wood have been developed for certain grades of board. Utilization of wastes in the product dealt with is of greatest interest to any manufacturer and is most likely to provide a permanent solution to the problem. Marginal by-products of limited market, the production of which necessitates large capital and operating investments and which often provide only a limited degree of effluent improvement, are becoming less attractive to manufacturers. The industry has experienced many such ventures and has seen them fail. Manufacturers will lean much more toward the use of wastes in products they understand and which their organizations are set up to produce and market. Hence this form of utilization holds the most promise for the future, and interest will increase as supplies of raw materials become less plentiful.

CHARACTERISTICS AND METHODS FOR TREATMENT OF DEINKING WASTES *

By Willard W. Hodge and Philip F. Morgan

Senior Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa., and Research Engineer, National Council for Stream Improvement, Kalamazoo, Mich. (formerly Industrial Fellow, Mellon Institute), respectively

The deinking of waste paper and its conversion into pulp suitable for use in the manufacture of different grades of paper is one of the comparatively newer branches of the pulp and paper industry. A number of papers have been published and patents granted describing different processes for deinking waste paper (16), but comparatively little printed information appears to be available on the properties of the waste materials from this industry or on methods for treating and disposing of the liquid wastes so as to abate water pollution. The shortage of new pulp during World War II caused a rapid growth in the application of deinking processes to old paper. The situation was summarized by Wakeman (13) in 1943 when he asked the question, "How are we going to make more than 15,000,000 tons of paper and paperboard with the amount of pulp we know we have available? From estimates today we are going to have about 8,500,000 tons of wood pulp available for paper and board production in this country. This will mean forcing the use of waste paper and other waste fibers up to the limit and further downgrading." A discussion by Jubb (8) along similar lines was also published. The question was partially answered by the increased production in the United States of deinked pulp from about 27,000 tons per month during the first half of 1943 to between 35,000 to 40,000 tons per month during 1944.

The geographical locations of 48 deinking mills and the comparative magnitude of the deinking industry in the United States are shown in Figure 1. The mills are concentrated quite largely in five states: Massachusetts, Pennsylvania, Ohio, Michigan and Wisconsin. The large number of deinking mills located in the Kalamazoo, Mich. region will be noted. It is for this reason that the National Council for Stream Improvement established a branch of the Mellon Institute Fellowship in Kalamazoo, to make not only supplementary laboratory studies on deinking wastes, but also to conduct stream pollution surveys, to investigate the tendency, if any, of deinking wastes to form sludge deposits on the river banks and bed, to make analyses of deinking mill operations and to determine the properties of liquid wastes obtained from each important unit operation applied in the processes. Information has been obtained regarding four deinking mills in Canada, and there may be others, but the abundance of pulpwood in this Dominion lessens the need for deinking plants.

A perspective of the relation of the deinking of waste paper to other activities of the pulp and paper industry is obtained from Government statistics (5, 6, 12). The total quantities of cellulosic raw materials consumed by the pulp and paper industries of the U. S. A. during 1939 were 14,084,700 tons, in 1944 were 18,746,762 tons and in 1945 were 18,988,631 tons. The

* Presented at the 19th Annual Meeting of the Federation of Sewage Works Associations; Toronto, Ontario, Canada; October 7, 1946.

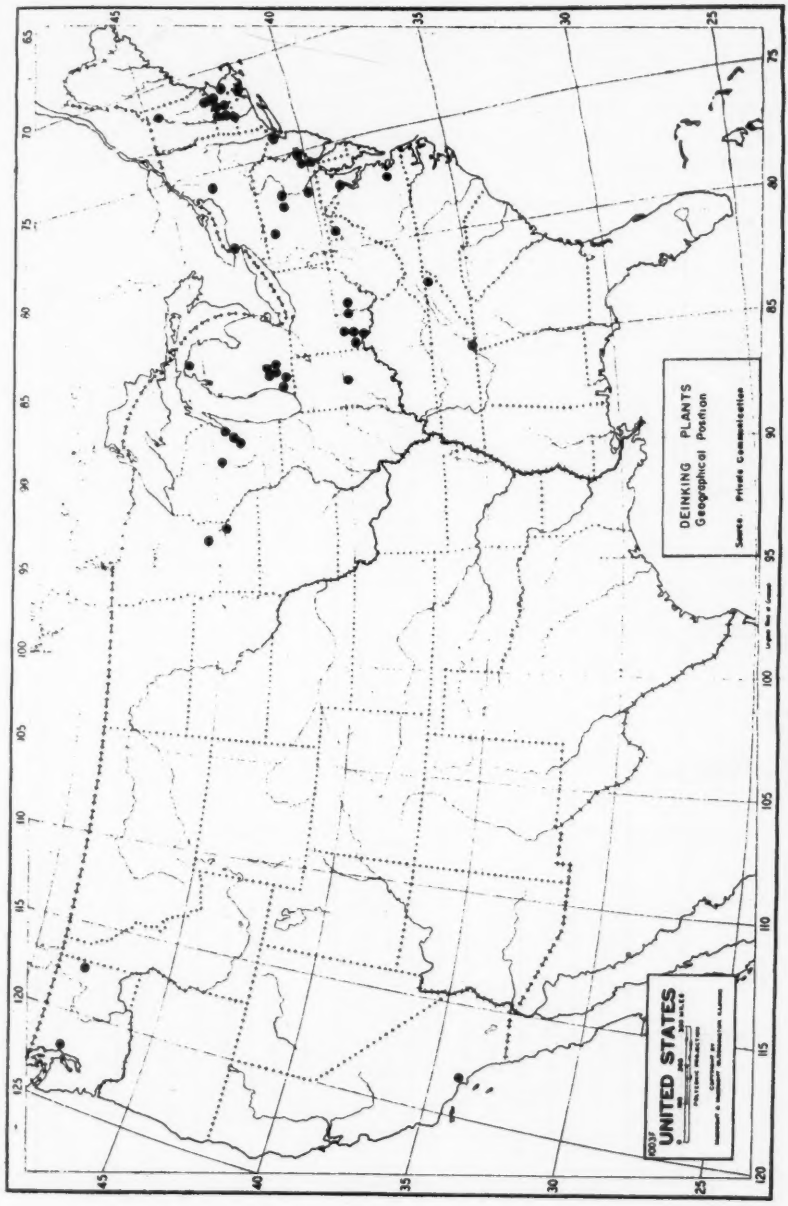


FIGURE 1.—Location of waste paper deinking plants in the U. S.

waste paper consumed amounted in 1939 to 4,366,257 tons, in 1944 to 6,859,332 tons, and in 1945 to 6,799,683 tons, or about 31 per cent in a prewar year to around 36 per cent in the last war year of the total cellulosic raw materials utilized. The production of pulp by deinking processes was equal to approximately 10 per cent of the waste paper consumed. The production of deinked pulp by months for the years 1943–44 is shown in Figure 2. In 1944 the total annual production of deinked pulp approached 400,000 tons.

Since the characteristics of the deinking wastes depend largely on the kinds of waste paper charged into the cookers or digesters, the type of process

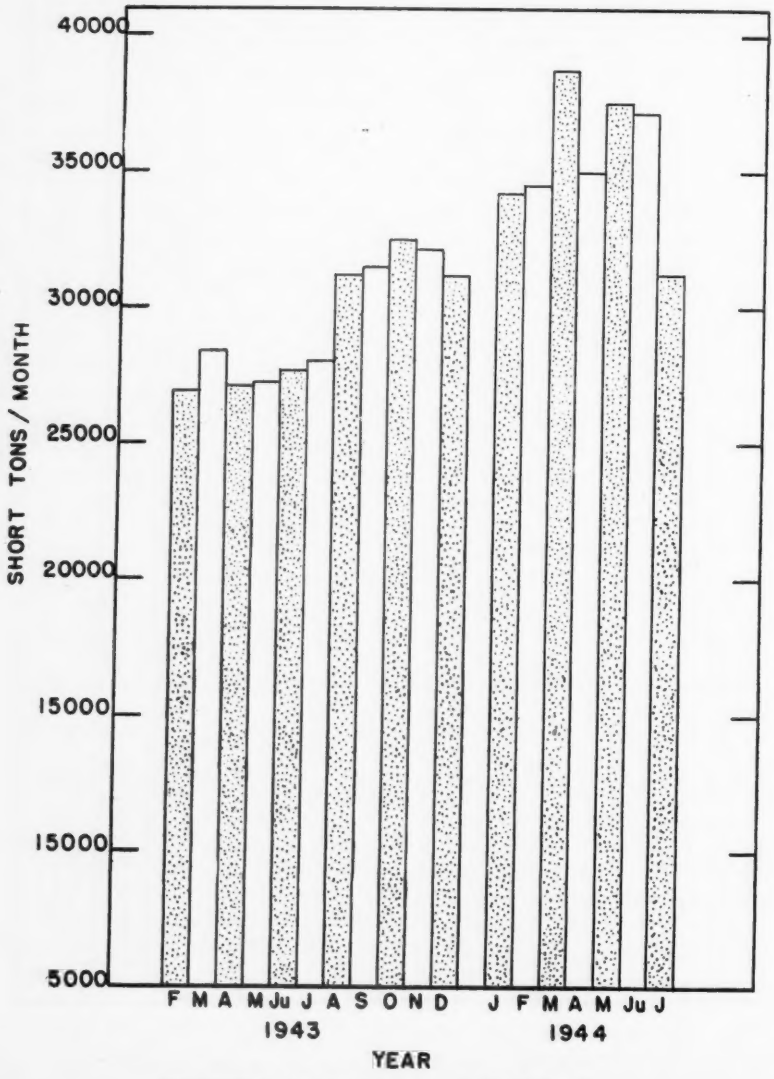


FIGURE 2.—U. S. production of deinked pulp.

and chemicals applied, and the quality and quantities of water used in manufacture, brief descriptions of these factors will be presented.

Quality of Paper Utilized and Quantity of Deinking Liquid Wastes

The average price paid for waste paper in the U. S. during 1939 was $13.12 per ton. For the better qualities of waste paper used by deinking companies to manufacture pulp for magazine, ledger, and book stock, according to Clark (3) an average price of about $38.71 was paid in 1942. Old papers made from ground wood pulp cannot be used in a fixed alkali process for the better grades of deinked pulp. Comparatively recently, however, Wells (15) has proposed processes for partial utilization of old papers containing ground wood pulp.

Since several washing operations are involved in the making of deinked pulp, the quantities of liquid wastes from a deinking plant are large. For cooking and washing the waste papers 10,000 to 20,000 gallons or more of water per ton of finished pulp may be required. The data for a few mills are as follows:

Plant No.	Pulp (tons per day)	Liquid Wastes from Ink Washing (g.p.d.)	Effluent (gal. per ton pulp)
1	200	1,960,000	9,700
2	233	2,400,000	10,300
3	24	850,000	36,000
4	55	608,000	11,000
5	55	1,700,000	31,000

Types of Deinking Processes

A great many different processes have been proposed for deinking waste paper and many of them have been patented (16). Most of the processes exhibit considerable similarity in the unit operations applied; the differences are in the methods, equipment and chemicals used. The usual successive unit operations used are as follows: opening the bales of paper; general inspection; sorting (sometimes done before baling and shipping);

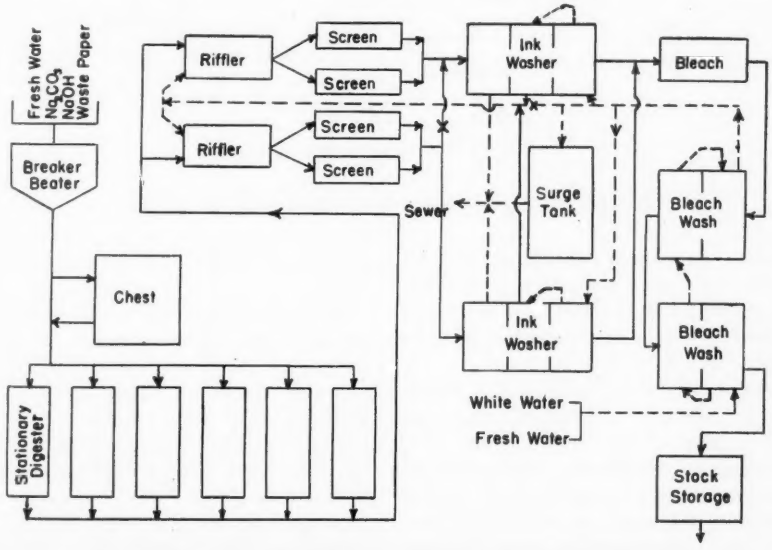


FIGURE 3.—Flow diagram of deinking operations—Mill F.

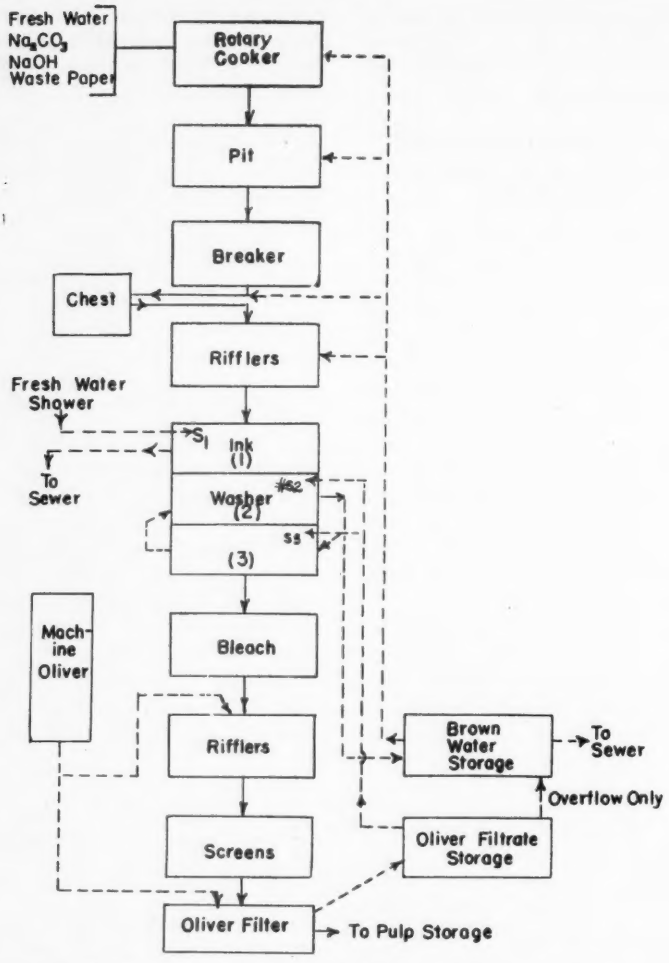


FIGURE 4.—Flow diagram of deinking operations—Mill I.

dusting; shredding; charging the boilers or digesters; cooking and defibering; riffling; screening; ink washing; bleaching; washing; stock chest or pulp storage.

This is a general outline of a deinking process, but variations in the kind and quality of the waste paper used may require modifications and different manufacturers do not always follow the same sequence of unit operations. The flow diagrams for two deinking mills are presented in Figures 3 and 4, and one of washery operations in Figure 5.

A general classification of the principal deinking processes in use is as follows: (1) the open cooker type, which operates at from about 180° F. to 200° F. The time of contact of the old paper with the hot cooking solution in either batch or continuous operation varies from 1 to 10 hours. Approximately 50 per cent liquor recovery is often attained. (2) The pressure cookers, in which the shredded

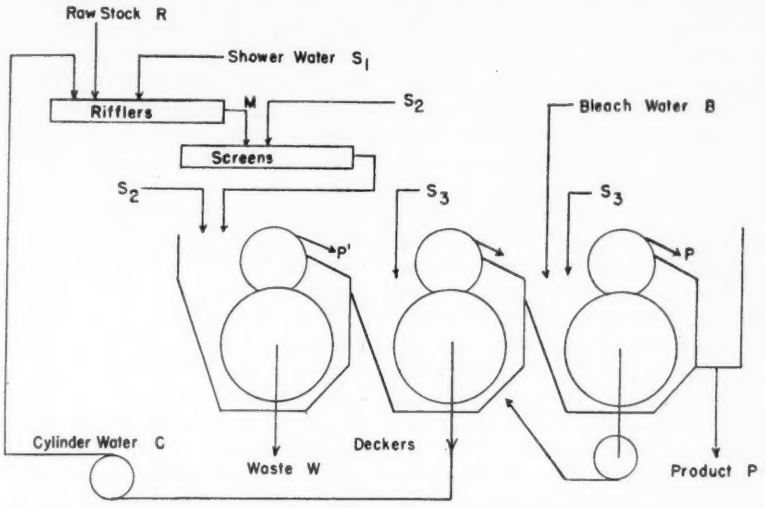


FIGURE 5.—Flow diagram of deinked pulp washing.

waste paper in contact with the caustic solutions is cooked at pressures of from 10 to 50 p.s.i. in rotary horizontal or spherical steel vessels. About 10 to 15 per cent of the cooking liquor is recovered in this type of process. (3) The hydrapulper type uses a large vertical steel tank, usually equipped with a centrifugal pump recirculating system. In some of the newer hydrapulper installations, however, the recirculation system is omitted. The pump acts as a pulping machine and after the old paper is sufficiently cooked the pulped stock is pumped without any liquor recovery directly to the washers and then to the finishing operations. In all these types of digesters, boilers or cookers, the chemicals and heat applied loosen the inks and fillers from the paper so that they can be removed in the washing operations.

Printers inks have been classified by Bragg (1) into three main groups:

"(a) Alkali-saponifiable inks, in which the pigment is dispersed in a saponifiable vehicle, usually linseed oil:

1. Indelible inks—resistant to water.
2. Printing inks containing rosin, mineral oil, and carbon black.

"(b) Nonsaponifiable inks:

1. Metallic inks (aluminum, gold, or bronze powder plus varnish).
2. Poster and sign inks (mineral oil with carbon black).

"(c) Special inks, alkali-resistant:

1. Rotagravure inks—oxidized asphalts and gilsonite base.
2. Vaporin 'flash-drying ink' (synthetic resin and pigment blended with an organic solvent or vehicle, usually of the hydrocarbon type). The solvent is removed by passing printed paper through gas-fired heaters.
3. 'Cold set' inks, consisting of a thermoplastic resin and pigment. The ink and type are heated so that the ink is fluid; after printing the ink sets quickly on the cold paper."

The kinds of inks and vehicles applied in printing the paper, as well as the filler, size and quality of paper used, are important factors in the choice of process installed to deink the

waste paper and are largely responsible for the materials present in the spent cooking liquors and wash water discharged from the deinking plants.

The more commonly used chemicals for cooking the waste paper are sodium hydroxide, sodium carbonate, or a mixture of these two compounds; sodium silicate and other alkaline detergents have been used. Cooking the old paper in the alkaline solution saponifies the oil and/or resin vehicle of the ink, thus loosening the ink from the paper. The alkali may also saponify any rosin size present in the paper and have a hydrolytic effect on any starch or casein size present. The presence of large amounts of casein size in the waste liquors was found by Eldridge (4) to have a detrimental effect on coagulation and settling of suspended solids. The freed ink, clay filler, coloring pigments or dyes, saponified vehicle and sizing materials are washed away from the pulp in the washers and are present in the waste deinking cooking liquors and wash waters. The cellulose fibers, after removal of any solid foreign material by the riffles and screens and thorough washing, may flow to the bleachers and bleach washers, then to storage chests or to the Hollanders in which some new pulp may be added and the mixture beaten to the correct consistency for transfer to the stock chest, or to a filter and to storage for later use.

Other chemicals added to the cooking liquors for specific purposes as given by West (16) are: *detergents* such as sodium soaps of fatty acids, sodium silicate, sulfonated oils, fats, aliphatic alcohols or by-products from petroleum refining, or bentonite in presence of alkali and trisodium phosphate or tetrasodium pyrophosphate; some of these materials, especially the sulfonated organic compounds, may serve as *dispersing agents* to prevent agglomeration of the pigment after it is released from the fibers and to emulsify any nonsaponifiable mineral oil or wax present. A patent granted to Welch (14) proposes the use of waste sulfite liquor containing lignin sulfonic acids, which are said to have inherent dispersing properties. To dissolve or *soften* any gilsonite, oxidized vehicle or synthetic resins which are often present in some recently developed inks, small quantities of kerosene or other mineral oil, carbon tetrachloride or other suitable solvent may be added. For the *selective adsorption* of the pigment after it is freed from the fiber and to prevent its redeposition clay filler, bentonite, or silica gel may serve the purpose. If the wash water is very hard a *base exchange* material such as tetrasodium pyrophosphate or hexasodium metaphosphate may be applied to prevent the formation of insoluble calcium soaps.

Acid processes have also been proposed for deinking waste paper. One such process covered by United States (10) and Canadian (10) patents would treat the old paper with two parts of sulfurous acid plus one part of sodium carbonate in a digester. It is claimed that this process not only removes the ink from the fiber but also bleaches the pulp by the sodium sulfite formed in the cooking operation.

The use of many other chemicals and kinds of equipment has been proposed for deinking waste paper. Some have gone through pilot plant investigations and there have been a few industrial installations. However, the extensive researches on deinking wastes carried on by the National Council for Stream Improvement multiple fellowship at Mellon Institute and its Branch Project at Kalamazoo College have dealt with the digester waste liquors and pulp wash waters resulting from cooking different kinds of waste paper with solutions of caustic soda, soda ash or a mixture of these two chemicals. Thirty-two samples of from 15 to 50 gallons of deinking wastes from two mills in each state, Michigan, Ohio and Pennsylvania, have been used

for study at the Mellon Institute laboratory and many similar samples from the Michigan mills and several others have been studied at the National Council's project in Kalamazoo.

Characteristics of the Deinking Wastes

The chemicals, ink, vehicle, pigments, filler and size from the waste paper, together with small amounts of short broken fiber, are contained in the liquid wastes from the deinking mills. The spent cooking liquors and wash waters are usually discharged together in the effluent from the plant. The samples of deinking wastes varied in color from light gray to dark gray, with an occasional sample nearly black. The fresh samples had little or no odor, but after storage a few of the samples developed some hydrogen sulfide. The effects of age on other properties of the deinking wastes are shown in Table I. There was a gradual decrease in pH, but the alkalinity to methyl orange indicator increased. The quantities of total solids and the B.O.D. decreased appreciably. With highly alkaline wastes no hydrogen sulfide was observed, but some of the weakly alkaline wastes developed a strong odor of H_2S after comparatively short storage periods. Since H_2S is very objectionable in atmospheric or liquid wastes, this factor should be considered in planning the detention periods for deinking wastes in lagoons or settling basins.

The data in Table II show that the overall liquid wastes from deinking mills investigated to date were from 99.35 to 99.91 per cent water. The total solids at 105° C. varied from 910 to 6,500 p.p.m. Volatile matter in the total solids varied from 35.67 to 60.16 per cent; this is assumed to be largely waste fiber. The suspended solids ranged from 570 to 3,072 p.p.m., the balance of the total solids being composed of previously dissolved materials. Turbidities varied from 1,000 to 3,200 p.p.m. The volatile matter in the suspended solids ranged from about 30 to 42 per cent. The fixed solids or ash was composed largely of clay filler, inorganic pigments and carbon not burned off at from 600° to 650° C.

TABLE I.—Effect of Age on Deinking Wastes Stored in Covered Containers

Mill and Sample Nos.	B–3	B–3	E–4	E–4
Date	12–10–45	2–5–46	1–23–46	2–5–46
Age[1] (Days)	—	59	—	13
pH	11.41	7.68	9.20	7.65
Turbidity (p.p.m.)	1050	1000	1800	1700
Alkalinity as $CaCO_3$, P[2] (p.p.m.)	110	0	0	0
Alkalinity as $CaCO_3$, M.O.[2] (p.p.m.)	304	330	502	567
Total Solids (p.p.m.)	1816	1545	2787	2670
Moisture, 105° C. (%)	99.82	99.85	99.72	99.73
Volatile Solids, Dry Basis (%)	51.63	50.70	40.70	42.69
Suspended Solids (p.p.m.)	867	934	1657	1534
Volatile (p.p.m.)	363	411	490	484
Fixed (p.p.m.)	504	523	1167	1050
Dissolved Oxygen (p.p.m.)	4.6	5.2	1.5	3.7
5-Day B.O.D. at 20° C. (p.p.m.)	410	340	460	340

[1] Age of samples is given as the amount of time elapsed between the first analysis made and the next date indicated; as some time in transit had already passed before first analysis in Pittsburgh laboratory was made.

[2] P = Phenolphthalein alkalinity; M.O. = total alkalinity to methyl orange.

Notes: An unexplainable increase was found in the suspended solids content of B–3 after ageing. Suspended solids in E–4 decreased.

The 5-day B.O.D. of both samples decreased: B–3, 17.1 per cent and E–4, 26.1 per cent. This has been found in practice in lagooned wastes from several types of paper mill wastes.

TABLE II.—Summary of Analyses of Original and Settled Deinking Wastes

Sample No.	Color as Received	Turbidity (p.p.m.)	pH	Alkalinity (p.p.m.)		Total Solids (p.p.m.)	Moisture (%)	Suspended Solids (p.p.m.)			5-Day B.O.D. at 20° C. (p.p.m.)
				Phenol-phthalein	Methyl Orange			Total	Vol.	Fixed	
A–1	Dark Gray	—	9.87	80	680	3790	99.62	—	—	—	—
A–2	Dark Gray	1200	11.30	176	740	3400	99.66	1641	555	1086	—
A–2S*	—	430	8.50	130	738	2165	99.78	164	65	99	—
A–3	—	—	8.32	27	396	940	99.91	—	—	—	From lagoon
A–4	Dark Gray	2100	10.20	316	952	5065	99.49	2995	1115	1880	—
A–4S	—	1500	9.50	130	608	3105	99.69	635	217	418	—
A–5	Dark Gray	1800	10.54	221	1014	2900	99.71	1379	456	923	—
A–5S	—	750	10.42	186	854	2070	99.79	405	94	311	—
A–6	—	—	—	—	—	—	—	—	—	—	Sludge from lagoon
A–7	Black	215	8.14	0	515	920	99.91	60	21	39	—
A–8	Dark Gray	3000	11.87	830	2390	6500	99.35	2851	877	1974	—
A–9	Dark Gray	2500	12.21	500	1266	4399	99.56	2156	915	1241	640
A–9S	—	1250	11.98	485	1088	2899	99.71	332	82	250	400
A–10	Medium Gray	2200	11.57	255	900	3842	99.62	2010	908	1102	660
A–11	Gray	2000	11.23	277	984	3683	99.63	1769	639	1130	610
A–11S	—	1250	11.22	280	852	2712	99.73	667	208	459	460
B–0	—	—	11.58	352	1094	3770	99.62	—	—	—	—
B–0L	—	—	11.34	308	912	2260	99.77	—	—	—	From lagoon
B–1	Light Gray	600	8.56	0	148	910	99.91	570	362	208	—
B–1S	—	140	7.61	0	123	460	99.95	46	36	10	—
B–2	—	2200	7.99	12	336	2430	99.76	1643	1056	587	—
B–2S	—	385	7.48	0	211	810	99.92	267	98	169	—
B–3	Light Gray	1050	11.41	110	304	1816	99.82	867	363	504	410
B–3S	—	300	11.62	110	278	1164	99.88	101	31	70	310
B–4	Light Gray-Tan	850	8.60	—	—	1426	99.86	745	278	467	480
B–7	Light Gray	690	6.84	—	—	1509	99.85	595	260	335	345

* Note: An "S" following the sample number indicates that this is the analysis of the supernatant liquid from the settled sample.

TABLE II.—Summary of Analyses of Original and Settled Deinking Wastes (Cont.)

Sample No.	Color as Received	Turbidity (p.p.m.)	pH	Alkalinity (p.p.m.)		Total Solids (p.p.m.)	Moisture (%)	Suspended Solids (p.p.m.)			5-Day B.O.D. at 20° C. (p.p.m.)
				Phenol-phthalein	Methyl Orange			Total	Vol.	Fixed	
C-1	Gray	2500	8.25	0	875	3650	99.64	2367	891	1476	—
C-1S*	—	173	7.62	0	330	1415	99.86	155	57	98	—
C-2	Gray	1700	7.68	0	495	3729	99.63	1979	633	1346	620
C-2S	—	1050	7.42	0	307	2382	99.76	604	272	332	260
C-3	—										Sludge
D-1	Light Gray	1600	7.98	0	614	2815	99.72	1275	536	739	—
D-1S	—	350	8.10	0	532	1620	99.84	190	76	114	—
D-2	Light Gray	1000	8.27	0	465	2675	99.73	1151	452	699	580
D-2S	—	450	7.50	0	410	1800	99.82	265	75	190	370
E-1	Dark Gray	3200	7.60	0	1020	4205	99.58	2628	739	1889	—
E-1S	—	1400	6.90	0	732	2575	99.74	1057	351	706	—
E-2	Gray	2600	7.70	0	840	3900	99.61	2318	687	1631	—
E-2S	—	1200	7.46	0	710	2400	99.76	846	250	596	—
E-3	Dark Gray	2900	9.20	45	795	3676	99.63	2094	663	1431	670
E-3S	—	1250	8.59	0	649	2554	99.74	777	214	563	495
E-4	Gray	1800	9.20	0	502	2787	99.72	1683	490	1193	460
E-5	Gray	715	8.01	—	—	1304	99.87	718	464	254	—
E-6	Gray										
F-1	Gray	2500	8.69	60	1090	5060	99.49	2904	1094	1810	—
F-1S	—	900	7.65	0	708	2375	99.76	446	122	324	—
F-2	Gray	1800	8.20	—	—	—	—	—	—	—	Previously settled
F-4	Gray	2500	8.20	0	968	5340	99.47	3072	1204	1868	—
F-4S	—	1000	7.10	0	670	2585	99.74	501	145	356	—
F-5	Dark Gray	3000	8.30	0	1025	5320	99.47	2990	890	2100	700
F-5S	—	1700	7.51	0	830	3455	99.65	662	189	473	590
F-6	—	—	—	—	—	—	—	—	—	—	Sludge

* Note: An "S" following the sample number indicates that this is the analysis of the supernatant liquid from the settled sample.

The B.O.D. of the mixed total effluents varied from 345 to 1,135 p.p.m. Separation of the suspended solids removed about 11 to 37 per cent of the B.O.D. (one exception, 58 per cent removed); hence, the larger portion of the B.O.D., as shown in Table III, is in the dissolved state. This makes the problem of reducing the B.O.D. content more difficult than if it was largely in the easily removable suspended matter.

The suspended solids in the samples of deinking wastes, with a very few exceptions, settled rapidly; from 70 to 80 per cent being removed in from 2 to 4 hours as shown in Table IV and Figures 6, 7 and 8; only small additional amounts settled in 48 hours.

TABLE III.—B.O.D. Distribution in Deinking Wastes

Mill	Sample Date	5-Day B.O.D. (p.p.m.)		B.O.D. in Solution (%)
		Waste	Filtrate of Waste	
E	Nov. 12	530	378	71
	Dec. 27	374	315	85
	Dec. 28	558	456	82
	Dec. 28	380	336	88
	Average			82
F	Nov. 29	598	529	89
I	Feb. 1	1030	774	75
	Feb. 2	1135	803	71

The application of different chemical coagulants, as discussed later, produced a more rapid settling of suspended solids and better clarification.

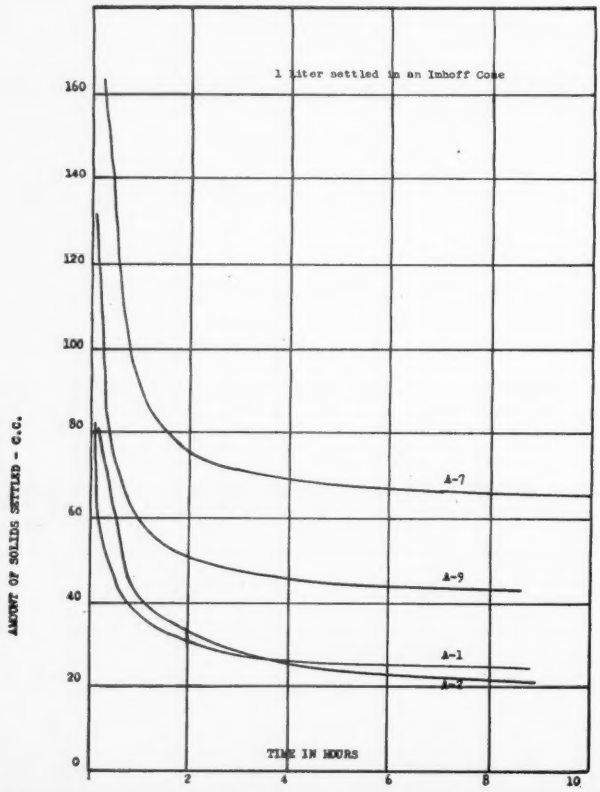


FIGURE 6.—Rate of plain settling of deinking wastes; four samples from Mill A.

Microscopical examination indicated (*Figure 9*) the suspended solids to be largely amorphous clay and pigment particles, pieces of broken fiber and occasionally a minute particle having a crystalline appearance. The quantities of sludge resulting from plain settling of the suspended solids varied considerably in volume and in total solids. Other properties of the sludges are given in Table V.

The large differences in the nature of the sludges from samples of deinking wastes from the same mill are evident by comparing the data from Samples A–2, A–4 and A–6 in Table V. The sludges resulting from chemical treatments of the deinking wastes also

TABLE IV.—Removals Effected by Plain Settling of Six Different Deinking Wastes

(Results in parts per million except as indicated)

Sample No.	Turbidity	Alkalinity as $CaCO_3$		Total Solids	Per Cent Reduction Suspended Solids			Dissolved Oxygen	5-Day B.O.D. at 20°C.	Tot. Nitrogen as N (Orig. $+NH_3$)
		P.*	M.O.**		Total	Volatile	Fixed			
Mill A										
A–2 (2)	71.33	26.14	0.27	36.32	90.01	88.29	90.88	—	—	—
A–4 (7)	28.57	58.86	36.13	38.70	78.80	80.54	72.45	—	—	—
A–5 (10)	58.33	15.84	15.78	28.62	70.63	31.80	89.72	—	—	—
A–9	50.00	3.00	14.06	34.10	84.60	91.04	79.85	6.85	37.50	—
Mill B										
B–1 (8)	76.67	—	16.89	49.45	91.93	90.06	95.19	—	—	—
B–2 (9)	82.50	100.00	37.20	66.67	83.75	90.72	71.21	—	—	—
B–3	71.43	0	8.55	35.90	88.35	91.46	86.11	—	24.39	18.10
Mill E										
E–1 (6)	56.25	—	28.24	38.76	59.78	52.50	62.63	—	—	—
E–2	53.85	—	15.48	38.46	63.50	63.61	63.46	—	—	—
E–3	56.90	100.00	18.36	30.52	62.89	67.72	60.66	—	26.12	—
Mill F										
F–1	64.00	100.00	35.05	53.06	84.64	88.85	82.10	—	—	—
F–4	60.00	—	30.79	51.59	83.69	87.96	80.94	—	—	—
F–5	43.33	—	19.02	35.06	77.86	78.76	77.48	—	15.71	—
Mill C										
C–1 (2)	93.08	—	62.29	61.23	93.45	93.60	93.36	—	—	—
C–2	32.35	—	37.98	36.13	69.48	57.03	75.33	—	58.06	77.80
Mill D										
D–1 (13)	78.13	—	13.36	42.45	85.10	85.82	84.57	—	—	—
D–2	55.00	—	11.82	32.71	76.98	83.41	72.82	—	36.21	28.03

* P. = Phenolphthalein alkalinity. **M.O. = Total alkalinity to methyl orange.

Note: Numbers in parentheses refer to original sample numbers.

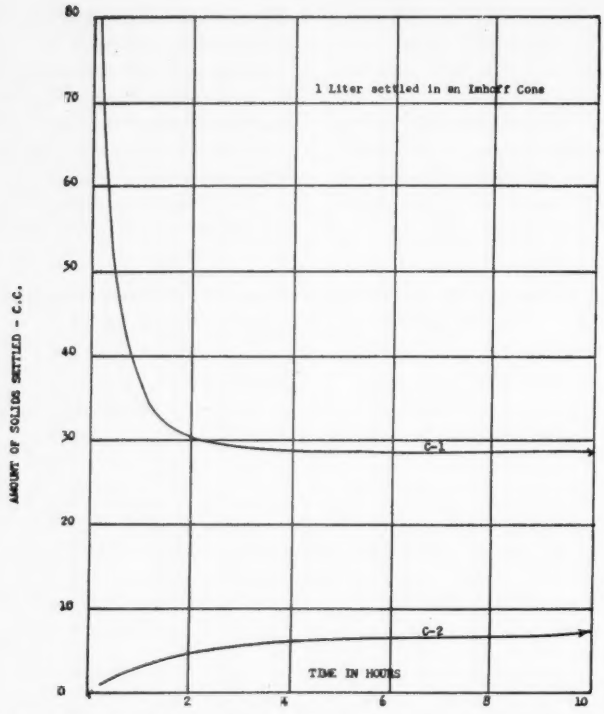


FIGURE 7.—Rate of plain settling of deinking wastes; two samples from Mill C.

varied widely in quantity and in some properties.

TABLE V.—Analyses of Sludges from Plain Settling of Deinking Wastes

Mill and Sample No.	Moisture (%)	Total Solids (%)	Solids—Dry Basis (%)	
			Volatile	Fixed
	Settled at the Mill for 1½ to 2 hours			
A–6	96.81	3.19	39.14	60.86
C–2	98.43	1.57	44.32	55.68
F–6	98.63	1.37	33.96	66.04
	Settled at Mellon Institute for 48 hours			
A–2	95.90	4.10	37.70	62.30
A–4	98.06	1.94	44.33	55.67
E–1	98.25	1.75	29.68	70.32

Effects of Deinking Wastes on a Receiving Waterway

The objectionable properties of deinking wastes from the standpoint of stream pollution are: (1) the large quantities of suspended solids in the wastes which cause high turbidity in the receiving stream and which might cause sludge deposits under certain conditions; (2) the rather high B.O.D. of the wastes, which diminishes the oxygen normally dissolved in open waters that is necessary for fish and other forms of aquatic life; (3) the muddy gray to almost black color of the wastes which makes the receiving waters unsightly. Very few if any reports have been received of complaints due to excessive foam formation on the stream surface or of disagreeable tastes or odors in water supplies into which

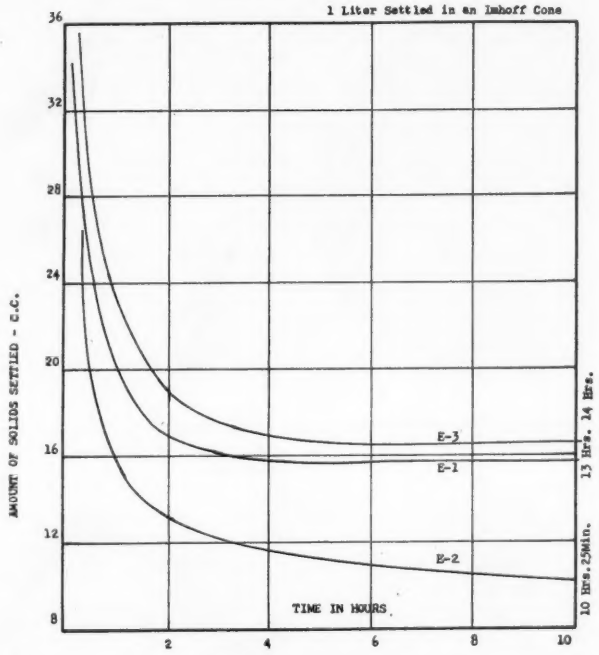


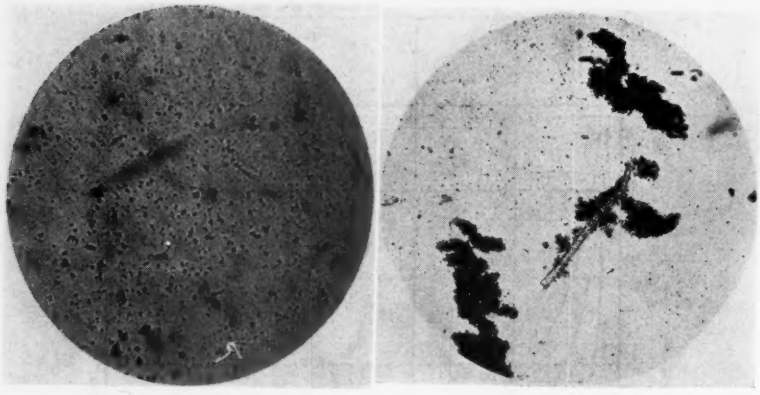
FIGURE 8.—Rate of plain settling of deinking wastes; three samples from Mill E.

deinking wastes have been discharged.

The probability of sludge deposits being formed from deinking wastes has been thoroughly investigated on the Kalamazoo River by the staff of the National Council research project at Kalamazoo, Mich. A cross-section survey was made of this river for sludge deposits. Aerial photographs were also utilized in the search for sludge deposits but no large deposits were found in the free-flowing sections of this river. The mill ponds below the critical oxygen depletion portion of the river did have some sludge deposits, which may be partially due to paper mill wastes.

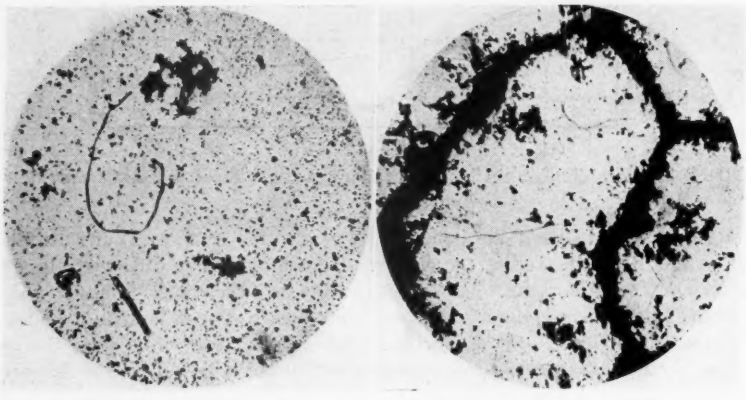
It was reported that heretofore there had been many complaints and much blame on the pulp and paper companies because of supposedly large deposits of sludge from deinking and other pulp and paper mill wastes. The survey showed, however, that the river bottom was clean. A 3- to 12-in. deep layer of muck or sludge did exist along both banks of the river for considerable distances. These layers of muck did not extend very far into the river, usually less than 10 feet. Apparently the sludge deposits in this part of the stream are small and do not at present constitute a serious river condition. These observations may be of considerable value in deciding on the required degree of removal of suspended matter in industrial wastes when they are to be discharged into streams having sufficient volume and velocity of flow to float the suspended solids away without the formation of objectionable sludge deposits.

The effects on the dissolved oxygen in the Kalamazoo River of the untreated sewage load from Kalamazoo, Mich. (56,000 population), the deinking and other pulp and paper mill wastes, and other industrial wastes



(a) Suspended solids in well mixed waste; sample No. B–4.

(b) Sludge deposited during second part of plain settling period; No. B–4.



(c) Suspended solids in well mixed waste; sample No. E–5.

(d) Sludge deposited during plain settling period; No. E–5.

FIGURE 9.—Microscopical appearance of deinking wastes.

have been investigated by partial stream pollution surveys. Utilizing the very limited data available, Prof. C. J. Velz, Head of the National Council Research Project on Stream Analysis, has plotted a number of oxygen sag curves, two sets of which are presented in Figures 10 and 11. This river entered the city of Kalamazoo in good condition, with a dissolved oxygen content of about 90 per cent saturation. Upon receiving the municipal sewage, deinking and other industrial wastes the dissolved oxygen in the river soon dropped to about 20 per cent of saturation and the B.O.D. of the river water had increased. In the drought year of 1930 the dissolved oxygen in the river was entirely depleted at the Plainwell sampling station. The river had recovered considerably at Allegan, some 35 miles downstream from Plainwell. The population equivalent of the deinking

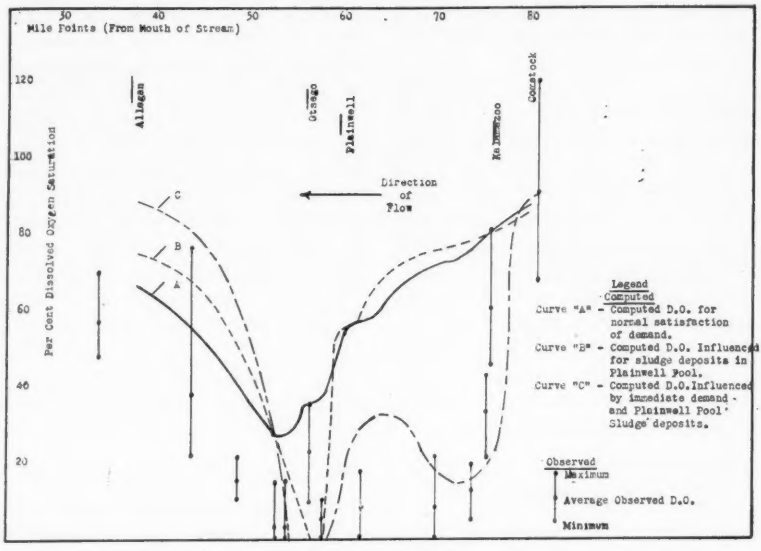


FIGURE 10.—Observed and computed dissolved oxygen content of Kalamazoo River under summer drought conditions.

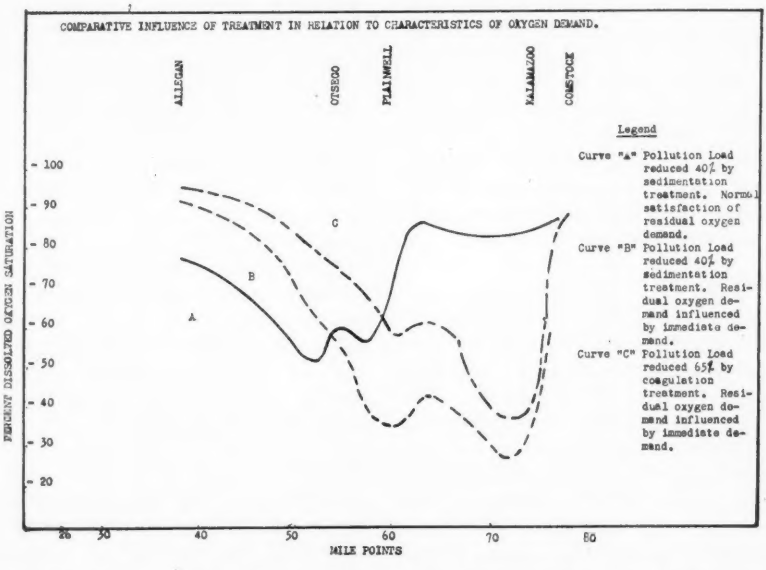

COMPARATIVE INFLUENCE OF TREATMENT IN RELATION TO CHARACTERISTICS OF OXYGEN DEMAND.
ALLEGAN
OTSEGO
PLAINWELL
KALAMAZOO
COMSTOCK
PERCENT DISSOLVED OXYGEN SATURATION
MILE POINTS
A
B
C
Legend
Curve "A" Pollution Load reduced 40% by sedimentation treatment. Normal satisfaction of residual oxygen demand.
Curve "B" Pollution Load reduced 40% by sedimentation treatment. Residual oxygen demand influenced by immediate demand.
Curve "C" Pollution Load reduced 65% by coagulation treatment. Residual oxygen demand influenced by immediate demand.

FIGURE 11.—Computed dissolved oxygen content of Kalamazoo River under summer drought conditions.

wastes from three of the eight mills in the district has been estimated at 110,400 on the basis of 0.167 lb. B.O.D. per capita per day.

During the summer of 1946 the National Council Kalamazoo Project, in cooperation with the Michigan Stream Control Commission, the U. S. Geological Survey, the pulp and paper companies in the Kalamazoo area, and the National Council Manhattan College Project, have made a comprehensive stream pollution survey of the Kalamazoo River. Based on the wealth of data obtained in the course of this survey a more complete and accurate stream analysis of the river may be available for a later paper.

Methods for Treatment of Deinking Wastes

Several extensive researches have been carried on to discover and develop satisfactory methods for reducing the turbidity, color and B.O.D. of deinking wastes. The following methods for clarification of deinking wastes have been investigated to date: plain sedimentation, including lagooning, dilution, heating, filtration, centrifuging, treatment with gases, and with many chemical coagulants; for removal of color, chemical coagulants and solid adsorbents; and for lowering the B.O.D., chemical treatments and aeration without and with addition of sewage.

Sedimentation

Plain settling or sedimentation removed usually from 70 to 80 per cent of the suspended solids in from 2 to 4 hours (Figures 6, 7 and 8). For example, one deinking waste contained 2,010 p.p.m. suspended solids; this was reduced after 2 hours of plain settling to 554 p.p.m., after 4 hours to 511 p.p.m., after 24 hours to 355 p.p.m., and after 48 hours to 323 p.p.m. These were reductions, respectively, of 72.4, 74.5, 87.2 and 88.9 per cent. One or two deinking wastes received did not clarify very much even after a 24-hour period of plain settling. The suspended solids weighed after drying at 105° C. varied in the samples of deinking wastes received from 570 p.p.m. to 3,072 p.p.m. (4.76 to 25.64 lb. per 1,000 gal.). Since some mills discharge from 3 to 5 m.g. of liquid deinking wastes per day the disposal of thousands of tons of wet settled sludge per year would be an important factor in the design of a waste treatment plant. The turbidities of the deinking wastes received ranged from 600 p.p.m. to 3,200 p.p.m., with an average from 12 samples of 2,004 p.p.m. (Table VI). In general the turbidities were not reduced by plain sedimentation as much as were the suspended solids.

Lagooning of Deinking Wastes

Investigations were made on the effluents from the lagoons into which two pulp and paper mills discharge their wastes. One of the mills has a single large lagoon, 60 acres in area, 30 ft. deep and with estimated detention period of 3 months. At the other mill there are four smaller lagoons, each one lower than the preceding one so that the wastes flow from one to the next in series and are aerated to some extent. Reductions in suspended solids range from around 71 to 98 per cent and in turbidities from about 63 to 93 per cent (Table VII). Apparently plain sedimentation, where plenty of land of favorable topography is available, is one method by which the suspended solids and turbidity of deinking wastes can be greatly reduced, but this method may not be so satisfactory from other standpoints.

Dilution

Dilution of deinking wastes with tap water at Mellon Institute retarded somewhat the settling of suspended solids in all but one of the samples tested. The effects of dilution on the rate of settling and compaction of suspended solids are shown in Figure

TABLE VI.—Analyses of Twelve Representative Deinking Wastes

Sample No.	A–2	A–9	B–1	B–3	C–1	C–2	D–1	D–2	E–1	E–3	F–4	F–5	Avg.
Turbidity (p.p.m.)	1500	2500	600	1050	2500	1700	1600	1000	3200	2900	2500	3000	2004
pH	11.30	12.21	8.56	11.41	8.25	7.68	7.98	8.27	7.60	9.20	8.20	8.30	9.08
Alkalinity to P.[1] (p.p.m.)	176	500	0	110	0	0	0	0	0	45	0	0	69
Alkalinity to M.O.[2] (p.p.m.)	740	1266	148	304	875	495	614	465	1020	795	968	1025	726
Moisture at 105° C. (%)	99.66	99.56	99.91	99.82	99.64	99.63	99.72	99.73	99.58	99.63	99.47	99.47	99.65
Total solids at 105° C. (p.p.m.)	3400	4399	910	1816	3650	3729	2815	2675	4205	3676	5340	5320	3495
Volatile solids, dry basis, at 600° C. (%)	48.75	44.96	60.16	51.63	40.52	41.03	50.48	45.66	36.07	42.60	45.55	35.67	45.26
Suspended solids, at 105° C. (p.p.m.)	1641	2156	570	867	2367	1979	1275	1151	2628	2094	3072	2990	1899
Volatile solids (fiber), at 600° C. (p.p.m.)	555	915	362	363	891	633	536	452	739	663	1204	890	684
Fixed solids (ash), at 600° C. (p.p.m.)	1086	1241	208	504	1476	1346	739	699	1889	1431	1868	2100	1216
B.O.D., 5-day at 20° C., mixed total effluent as rec'd. at Mellon Institute (p.p.m.)[3]	—	640	—	410	—	620	—	580	—	670	—	700	603

[1] P. = Phenolphthalein.
[2] M.O. = Methyl Orange.
[3] Average of 11 samples as received at Mellon Institute was 561 p.p.m.; average of 16 fresh samples as collected at Kalamazoo, Mich. was 562 p.p.m.

TABLE VII.—Removals Effected by Lagooning Deinking Wastes

Sample No.	pH	Turbidity (p.p.m.)	Alkalinity as $CaCO_3$ (p.p.m.)		Moisture (%)	Total Solids (p.p.m.)	Solids—Dry Basis (%)		Suspended Solids (p.p.m.)			Oxygen Consumed (p.p.m.)	Total Nitrogen as N_2 (Org. $+NH_3$) (p.p.m.)
			P*	M.O.**			Vol.	Fixed	Total	Vol.	Fixed		
A–2	11.3	1500	176	740	99.66	3400	48.75	51.25	1641	555	1086	510	5.09
A–3	8.3	280	11	437	99.91	900	26.74	73.26	315	77	238	270	2.78
Per Cent Reduction	—	81.3	93.7	41	—	73.5	22.01	—	80.7	86.1	78.1	47	45.4
B–O	11.6	1500	352	1094	99.62	3800	57.20	42.80	1349	793	556	1000	9.85
B–OL	11.3	550	308	912	99.77	2300	42.98	57.02	390	237	153	280	5.44
Per Cent Reduction	—	63.4	12.5	16.6	—	39.5	14.22	—	71.1	70	72.5	72	44.8
A–8	11.9	3000	830	2390	99.35	6500	46.37	53.64	2851	877	1974	—	—
A–7	8.1	215	0	515	99.91	920	46.85	53.16	60	21	39	—	—
Per Cent Reduction	—	92.9	100	78.4	—	85.8	—	0.48	97.9	97.6	98.0	—	—

* P = Phenolphthalein alkalinity. ** M.O. = Total alkalinity (methyl orange).

Note: Samples A–2, A–3, A–8, A–7 are from the same mill; A–2 and A–8 are original deinking wastes and A–3 and A–7 after being lagooned. Samples B–O and B–OL are from the same mill, B–O being the original waste and B–OL after lagooning.

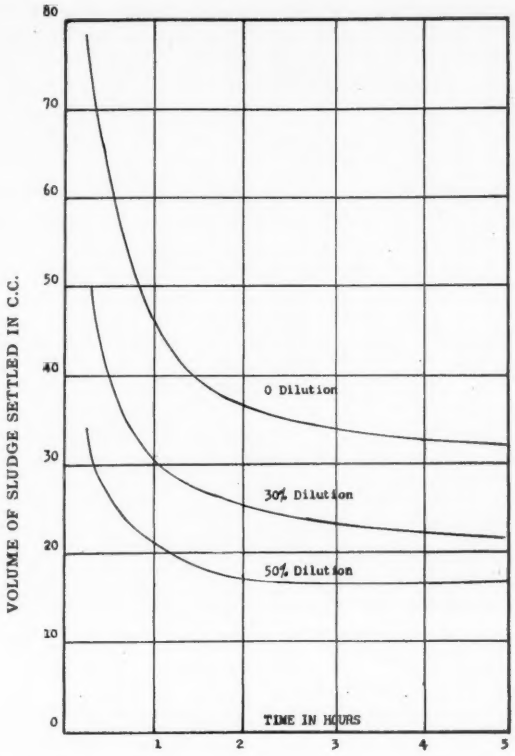


FIGURE 12.—Effect of dilution on settling and compacting of deinking waste.

12. A deinking waste from a Wisconsin mill was rapidly clarified by dilution with Fox River water, but was not so affected by dilution with the city water of Kalamazoo, Mich. Evidently the kind of deinking waste and nature of the dilution water are important factors to be considered in the treatment of deinking wastes by the dilution method. While this method may have certain applications for favorably located mills, as a general method for treatment of deinking wastes, based on results of laboratory tests, it cannot be recommended for clarification purposes.

Heating

Heating coagulates and hastens the settling of some organic materials, hence the possibility of using waste steam to heat deinking wastes was considered. Results of experiments showed little favorable effect of heating deinking wastes to different temperatures including boiling. Even if the laboratory tests had given favorable results, the costs for heating the million or more gallons of wastes per day would make this method prohibitive unless very large quantities of waste heat were available.

Filtration

Filtration of deinking wastes on a laboratory scale proved unsatisfactory. A special cylindrical filter was made which gave large surface area and contained a stirrer to keep the suspension of solids uniform during filtration, but

even with this apparatus poor results were obtained. If a filter paper or cloth of sufficiently fine texture to retain the very fine particles was used the rate of filtration soon became exceedingly slow and pressure required high, both factors making for high costs of operation and indicating the requirement of so many filters that this method would not be considered. When a coarser weave fabric was used as the filtering medium the filtrate was dark, almost black in some tests, and contained much colloidal matter.

Centrifuging

Centrifuging is another unit operation of chemical engineering often applied industrially to separate solid particles from the liquid in which they are suspended. Research at Mellon Institute with a 5-in. diameter basket laboratory centrifuge, using different mesh filter cloth liners in the basket, with and without prebuilt cake, filter aids, various rates of liquid flow and at velocities ranging from 1,800 r.p.m. to 6,000 r.p.m., all gave unsatisfactory results. For tests on pilot plant size centrifuges, 5-gal. samples of deinking wastes were sent to the Sharples Corporation and to the Bird Machine Company and they kindly cooperated in conducting the experiments. The report from the Sharples Corporation stated that with their laboratory super-centrifuge operated at half speed, giving a force 3,500 times gravity, there was some removal of suspended solids but the clarified effluent from the bowl still contained so much suspended and colloidal matter that the operation was considered quite ineffective. The Bird Company reported that the deinking waste could not be satisfactorily clarified in their continuous type centrifuge.

An important contribution to available information on centrifuging of deinking wastes has recently been received and is included in this report by special permission (9-a). A pilot plant Bird Continuous Centrifugal Classifier having a cylindrical bowl 18 in. in diameter by 28 in. was operated at 2,000 r.p.m. (which gave a force equal to 1,000 times gravity) on deinking waste. The flow varied from 2½ to 12 g.p.m., but no separation of solids was accomplished, even at the low feed. It was concluded that continuous separation of solids in a Bird centrifuge was not possible for the following reasons:

1. The small particle size and low specific gravity of the solids to be separated.
2. The large amount of turbulence set up in the machine by the internal discharging screw conveyor.
3. The low concentration of solids in the effluent—approximately 20 lb. per 1,000 gallons.

An economic analysis showed that this method of centrifugal separation was not feasible. "To handle the flow from the 1st cylinder deinking waste would require 16 centrifuges, each handling 100 gallons per minute. The cost of purchasing and installing these machines would run about $250,000 and require 50 h.p. per unit to operate. The power cost would be around $43 per day."

Chemical Coagulation

Clarification of deinking wastes by treatment with chemical coagulants * to remove suspended and colloidal matter has been extensively investigated. Researches on 28 different deinking wastes have been carried on using the conventional 1/10-gal. jar and a specially constructed 1-gal. jar (Figure 13) coagulation testing machines. Separate tests employing the follow-

* A preliminary paper on this extensive investigation, giving details of procedures, was presented by Miss H. Gladys Swope to the Division of Water, Sewage and Sanitation Chemistry of the A.C.S. at the national meeting in Atlantic City, N. J., April 8–12, 1946. This paper has not as yet been published.

FIGURE 13.—Coagulation studies; special equipment for 1-gal. jar tests.

ing coagulants were made on the waste liquors as received and on many of the supernatant liquids after plain settling: sulfuric acid; alum; lime; activated silica and alum; activated silica and lime; activated silica, lime and alum; ferric chloride; copperas; ferric sulfate; sodium aluminate in conjunction with alum, lime and certain iron salts; liquid aluminum chloride; monochloracetic acid; and waste pickle liquor. Extended investigations of the effects of rate of mixing the coagulant with the deinking waste showed this factor was very important. With the large coagulation testing machine a stirring rate of 60 r.p.m. for 5 min. followed by a rate of 25 r.p.m. for 15 min. gave the best floc formation. The best results in coagulation and precipitation of suspended and colloidal solids were in general obtained with lime or sulfuric acid, although lime with silica, and alum with silica, had the best effects on some deinking wastes, and waste pickle liquor gave good results in the few tests made with it. Tables VIII, IX and X indicate the methods applied and give typical data obtained in the many series of experiments run and the hundreds of analytical determinations made.

The results of these laboratory experiments indicate that with certain deinking wastes considerable savings in the costs of chemicals for treating the wastes would be made by plain settling of the suspended solids before applying the chemical coagulants; with other samples there was not so much difference in the estimated costs between applying the chemicals to the original deinking waste or to the supernatant liquid after a period of free settling. Another factor to be considered is that if treatment with sulfuric or other acid coagulant would make the waste too acid in reaction it would be necessary to add some lime

TABLE VIII. Clarification of Deinking Wastes by Sulfuric Acid

Mill and Sample No.	H_2SO_4 (gr./gal.)	pH	Turbidity (p.p.m.)	Alkalinity as $CaCO_3$ (p.p.m.)		Total Solids (p.p.m.)	Moisture (%)	Volatile Solids—Dry Basis (%)	Suspended Solids (p.p.m.)			5-Day B.O.D. at 20° C. (p.p.m.)
				P*	M.O.**				Total	Vol.	Fixed	
A–9	0	12.21	2500	00	1266	4399	99.56	44.96	2156	915	1241	640
	95	5.51	25	0	46	3175	99.68	22.35	12	4	8	410
B–3	0	11.5	1050	10	304	1816	99.82	51.63	867	363	504	410
	16	5.6	12	0	28	929	99.91	48.48	7.5	7.4	0.1	205
C–2	0	7.7	1700	0	495	3729	99.63	41.03	1979	633	1346	620
	84	3.9	64	cid		3543	99.65	30.91	35	25	10	340
D–2	0	8.1	1000	0	465	2675	99.73	45.66	1151	452	699	580
	37	4.4	30	0	6	2000	99.80	36.87	20	10	10	380
E–3	0	8.9	2900	45	776	3676	99.63	42.60	2094	663	1431	670
	60	5.3	23	0	85	2355	99.76	31.42	13	6	7	495
F–5	0	8.5	3000	0	1025	5230	99.48	35.67	2990	890	2100	700
	80	4.5	25	0	58	3430	99.66	20.28	13	5	8	440

* P = Phenolphthalein alkalinity.
** M.O. = Total alkalinity to methyl orange.

or other alkali to restore sufficient alkalinity in the effluent before discharging the treated waste into streams.

With the data given in Tables II, VIII, IX and X, and for a given flow of deinking wastes, calculated estimations can be made as to the total quantities of chemicals required, detention periods necessary, fixed and volatile (fiber) solids, sludge precipitated and B.O.D. Some data on estimated costs are given which indicate that the expenditure for the most favorably reacting chemicals necessary to treat certain original deinking wastes would be around $8 to $56 per million gallons. Usually the costs for chemical treatment of the supernatant liquid from plain settling were lower than for treating the original wastes. All the calculations are based solely on the results of laboratory experiments, and pilot plant investigations should as a general rule be run before large investments are made in industrial size treatment plants.

Treatment with SO_2, CO_2 and Air

The use of gases for treatment of deinking wastes has been investigated to some extent, applying in separate experiments: sulfur dioxide, carbon dioxide, and air. Carbon dioxide is present in considerable quantities and sulfur dioxide, when bituminous coal is used as the fuel, in appreciable amounts in the waste stack gases at most pulp and paper mills. Hence, these gases would be cheap chemicals to use if their effects on the liquid wastes were favorable.

With sulfur dioxide a rapid flow of the waste down through the glass tube packed with glass beads was found preferable to slow flow; the floc did not form until a pH of 4.5 was reached and good settling and clarification was obtained with the treated liquid at a 3.6 final pH.

The results of gassing deinking wastes with carbon dioxide were rather variable. In the two best runs after 4 hours of carbonation followed by a

TABLE IX.—Comparison of Effects of Plain Settling and Various Chemical Treatments on Deinking Waste E–3

Treatment	Dosage (gr./gal.)	pH	Turbidity (p.p.m.)	Alkalinity as $CaCO_3$ (p.p.m.)		Total Solids (p.p.m.)	Moisture—105° C. (%)	Volatile Solids, 650° C.—Dry Basis (%)	Suspended Solids (p.p.m.)			Dissolved Oxygen[1] (p.p.m.)	5-Day B.O.D. 20° C. (p.p.m.)	Color[2]
				P.	M.O.				Total	Vol.	Fixed			
None	0	8.9	2900	45	776	3676	99.63	42.60	2094	663	1431	1.2	670	Dark gray
Settled	0	7.8	1250	0	649	2554	99.75	48.22	777	214	563	4.9	495	Dark gray
H_2SO_4	60	5.3	23	0	85	2355	99.76	31.42	13	6	7	4.7	345	Orange
H_2SO_4	50	5.9	60	0	141	2319	99.77	33.56	37	16	21	4.8	395	Orange
Alum	49	7	96	0	356	1796	99.82	39.31	46	14	32	0.7	440	Orange
SiO_2+	0.425													
Alum	29	7.3	110	0	384	1686	99.83	44.64	86	36	50	1.7	420	Orange
Lime	55	12.4	15	660	884	1755	99.82	51.85	6	3	3	2.4	350	Orange
Lime	45	12.2	70	480	728	1717	99.83	56.06	36	13	23	3.9	430	Orange
SiO_2+	0.425													
Lime	32	11.9	25	234	441	1495	99.85	58.12	27	10	17	3.8	440	Orange
SiO_2+	0.300													
Alum+	24													
Lime	24	9.6	70	12	268	1632	99.84	49.22	54	23	31	0.0	440	Orange

Note: One-gal. sample used; temperature 18.5° C.

Samples mixed at 60 r.p.m. for 5 min., then stirred at 25 r.p.m. for 15 min. Chemicals added in order listed. Silica used was activated silica prepared with sulfuric acid. Suspended solids were filtered through Gooch crucibles using American asbestos. B.O.D.'s were run using supplemental seeded dilution water (standard dilution water which contains $FeCl_3$, $CaCl_2$, $MgSO_4$, and phosphate buffer). Seed used was 2 per cent settled sewage.

[1] Except for dissolved oxygen in original samples these D.O. results are those obtained on the sample set up for B.O.D.

[2] Color is that obtained in supernatant liquid after chemical treatment except in original sample.

TABLE X.—Reductions Accomplished by Plain Settling and by Chemical Treatments of Original Deinking Waste E–3 and of Its Supernatant Liquid after Plain Settling, E–3S

Treatment	Dosage (gr./gal.)	Cost* ($/1,000 gal.)	Final pH	Per Cent Reduction			
				Turbidity	Total Solids	Suspended Solids	5-Day B.O.D.
Original Deinking Waste E–3							
Settled	0	0.000	7.8	56.90	30.52	62.89	26.12
H_2SO_4	60	0.064	5.3	99.21	35.94	99.38	48.51
H_2SO_4	50	0.054	5.9	97.93	36.92	98.23	41.04
Alum	49	0.081	7.0	96.69	51.14	97.80	34.33
SiO_2+	0.425						
Alum	29	0.050	7.3	96.21	54.13	95.89	37.31
Lime	55	0.035	12.4	99.48	52.26	99.71	47.76
Lime	45	0.029	12.2	97.59	53.29	98.28	35.82
SiO_2+	0.425						
Lime	32	0.023	11.9	99.14	59.33	98.71	34.33
SiO_2+	0.300						
Alum+	24						
Lime	24	0.056	9.6	97.59	55.60	97.42	34.33
Settled Deinking Waste E–3S							
H_2SO_4	47	0.050	3.9	98.40	27.37	98.58	29.29
Alum	45	0.074	6.3	96.40	32.26	96.78	28.28
SiO_2+	0.625						
Alum	44	0.076	7.1	98.16	38.72	96.27	29.29
Lime	27	0.017	11.6	94.80	45.58	93.69	17.17
SiO_2+	0.325						
Lime	29	0.020	11.6	98.00	45.97	97.68	11.11
SiO_2+	0.325						
Lime+	22						
Alum	22	0.052	9.0	92.32	39.90	88.67	21.21

* All estimated costs based solely on results of laboratory experiments.

Base prices used: Sulfuric acid 66° Be.—$15.00 per ton; alum—$1.15 per cwt.; Lime—$9.00 per ton; sodium silicate "N" brand—$1.05 per cwt. in drums.

2-hour settling period, suspended solids were reduced from 934 to 202 p.p.m. and 5-day B.O.D. from 340 to 163 p.p.m.; and in the second sample from 1,534 to 654 p.p.m. and 340 to 230 p.p.m., respectively. In neither experiment was much of the colloidal matter removed.

Two other experiments were run applying carbon dioxide to deinking wastes prior to treatment with sulfuric acid. With one of the wastes precarbonation reduced the amount of acid required by about one-half; with the other waste approximately the same quantity of acid was required to obtain clarification as when no carbonation had been applied.

In view of some favorable results obtained, however, investigations of the effects of stack gases, preferably from a mill using high sulfur coal for fuel, are planned. The above tests were run with commercial gases in cylinders and it evidently would not be economical to purchase such gases for treating deinking wastes.

Bioaeration

Bioaeration of deinking wastes to reduce their B.O.D. and total solids content has proved partially successful when the waste is mixed with some sewage. The B.O.D. of several deinking wastes tested at Mellon Institute ranged from 400 to 700 p.p.m. and, in the supernatant liquid after plain settling of suspended matter, from 310 (one doubtful result was 260 p.p.m.) to 590 p.p.m. The results of tests on fresh samples at the Kalamazoo Station were of approximately the same order of magnitude. Additional tests made at the Kalamazoo laboratory on composite samples of waste liquors gave B.O.D. values ranging from 358 to 1,135 p.p.m. (Table XI); cooking liquors drained from raw stock had B.O.D.'s of from 2,150 to 2,430 p.p.m. (Table XII); and waste liquors and wash waters from Hollanders or beaters, washers, cylinders, Deckers and other unit operations (Figures 3, 4 and 5) gave 5-day B.O.D. values of from 79 to 718 p.p.m. (Table XIII).

The average B.O.D. of municipal sewage varies from around 125 to 250 p.p.m. The data given in Table III showed that from 71 to 89 per cent of the B.O.D. in deinking wastes was dissolved in the liquid while the much smaller portion was in the more easily removed suspended solids. This makes the problem of B.O.D. reduction more difficult than if the distribution of the B.O.D. was reversed. While the total B.O.D. of an average deinking waste is not high compared to some other pulp and paper mill wastes, such as spent sulfite liquors, which range in the order of 30,000 p.p.m. or higher, still the B.O.D. values of most of the deinking wastes tested were high compared with average municipal sewage. Hence, an extensive series of researches is in progress to ascertain the most

TABLE XI.—Summary B.O.D. and Solids Data On Deinking Wastes, Kalamazoo Project

Mill	Sample Date	Number of Samples Composited	Suspended Solids (%)		Total Solids (%)		B.O.D. (p.p.m.)
			Solids	Ash	Solids	Ash	
E	Oct. 5	1	—	—	—	—	358
	8	1	—	—	—	—	533
	17	1	—	—	—	—	613
	Nov. 12	1	0.216	69	—	—	530
	19	1	0.226	70	0.411	57	522
	Dec. 4	1	0.204	—	—	—	465
	8	8	0.203	69	0.364	58	450
	13	1	—	—	—	—	431
	27	15	0.183	73	0.319	64	374
	28	12	0.228	71	0.401	57	558
	28	12	0.183	71	0.308	56	380
	Jan. 21	1	0.169	75	0.299	59	478
	Average	—	0.201	71	0.350	59	474
F	Oct. 25	1	0.283	73	—	—	543
	31	8	0.292	64	0.465	54	—
	Nov. 29	1	0.284	70	0.484	58	598
	Average	—	0.286	69	0.475	56	570
I	Feb. 1	12	0.268	62	0.498	52	1030
	2	12	0.334	58	0.587	47	1135
	Average	—	0.301	60	0.543	50	1080

TABLE XII.—B.O.D.'s of Cooking Liquors Drained from Raw Stock and in Wash Waters from Experimental Washing of Diluted Raw Stock

(a) B.O.D. of Cooking Liquor Drained from Raw Stock:

Date	B.O.D. of Plant Waste (p.p.m.)	B.O.D. of Drained Liquor (p.p.m.)	Ratio
12/ 8/45	450	2150	1:4.8
12/27/45	347	2000	1:5.3
12/28/45	380	2420	1:6.4
12/28/45	558	2430	1:4.4

(b) B.O.D. of Wash Waters from Experimental Washing of Diluted Raw Stock; Run No. 7; Mill H; Mixture of Magazine and Ledger Cooked at 235° F. for 4 Hours:

Sample	Quantity (gm.)	Suspended Solids		Weight of Suspended Solids		B.O.D.	
		Solids (%)	Volatile (%)	Solids (gm.)	Volatile (gm.)	P.P.M.	Gm.
Diluted Raw Stock.....	320	0.9514	0.8176	3.040	2.615	—	—
1st Wash Water.....	280	0.1067	0.0317	0.299	0.089	833	0.2335
2nd Wash Water.....	295	0.0559	0.0203	0.165	0.060	107	0.0316
3rd Wash Water.....	315	0.0283	0.0125	0.089	0.039	45	0.0142
4th Wash Water.....	295	0.0219	0.0115	0.065	0.034	44	0.0130
Washed Stock.....	—	—	—	2.316	2.230	—	—
Total Wash Water plus Washed Stock.....	—	—	—	2.934	2.452	—	0.2923

Note: Washing and beating procedure—13.6 gm. of cooked stock direct from rotary cookers was diluted with 68 ml. of distilled water and beaten in Waring blendor for 15 sec., then further diluted with 238.4 ml. distilled water for washing.

Summary: Raw stock 86.0 per cent volatile suspended solids; washed stock 96.5 per cent volatile suspended solids; fiber yield 73.3 per cent; total B.O.D. 96.2 lb. per 1,000 lb. raw suspended solids.

economical method for reducing the B.O.D. of deinking wastes.

The first line of attack for reducing the B.O.D. was a series of experiments in which deinking wastes alone, sewage alone for control data, and mixtures of deinking wastes and sewage were aerated at different rates of air flow and for various periods of time. A specially assembled apparatus was used for the aeration investigations (Figure 14). After aeration for 5 hours, 10 hours or other time intervals, the air was shut off and the suspended solids allowed to settle for 2 hours. Then portions of the supernatant liquids were drawn off for chemical analyses and 5-day B.O.D. tests.

Results to date show that aeration of the deinking wastes alone up to 10 hours gave only 25 to 35 per cent reduction of B.O.D., about the same as was obtained by free settling. When small or large quantities of sewage were mixed with the deinking wastes the reduction of B.O.D. of the mixtures continued as long as aeration was continued, which was 10 hours in the earlier series of experiments.

A specific example of the effects of aeration is given by experiments on deinking waste E–4. The original B.O.D. of this waste was 460 p.p.m. After 5 hours aeration followed by a 2-hour settling period the B.O.D. of the supernatant liquid was 300 p.p.m., and after 10 hours aeration the B.O.D. was still 300 p.p.m. On the other hand the mixture of E–4 with 25 per cent sewage had an original B.O.D. of 375 p.p.m.; after 5 hours aeration the B.O.D. of the supernatant liquid was

TABLE XIII.—Quantities and Properties of Washer Wastes in Deinking Processes

(a) Flow Data:

Mill	Length of Continuous Record (days)	Average Flow		Per Cent of Time Washers Operated on Week Days		Maximum 1-hour Flow Rate (m.g.d.)
		One Washer in Operation (m.g.d.)	Two Washers in Operation (m.g.d.)	One Washer Only	Two Washers	
F	9	—	1.94	0	100	2.96
E	7	0.706[1]	—	96.5	0	0.800
I	1	0.627	0.911[1]	46.4	47.9	1.015

(b) Waste Analysis:

Mill	Number of Samples Averaged	B.O.D. (p.p.m.)	Suspended Solids (%)		Total Solids (%)	
			Solids	Ash	Solids	Ash
F	2	570	0.286	69	0.475	56
E	12	474	0.201	71	0.350	59
I	2	1080	0.301	60	0.543	50

(c) Quantity of Waste:

Mill	Average Flow (m.g.d.)	B.O.D. (lb./day)	Suspended Solids		Equivalent Population on Basis of B.O.D.[2]	Equivalent Population on Basis of Solids[2]
			Tons per Day	Volatile Fraction (tons/day)		
F	1.94	9230	23.2	7.2	55,200	277,000
E	0.680	2690	5.7	1.7	16,000	68,000
I	0.728	6560	9.15	3.7	39,200	363,000

305 p.p.m., and after 10 hours aeration the B.O.D. was 185 p.p.m. This was a reduction of 50.67 per cent in B.O.D. produced by 10 hours aeration.

In later aeration experiments the B.O.D. of a deinking waste having an initial 5-day B.O.D. of 480 p.p.m. was mixed with 5 per cent of sewage and the mixture aerated for 127.5 hours; the final B.O.D. of the supernatant liquids from the duplicate runs were 89 and 81 p.p.m. (Table XIV).

The results of the most recent investigations indicate that on long time aeration, without additions of sewage, the B.O.D. of deinking wastes can be greatly reduced. Further researches are under way to develop a biological flora which will reduce the B.O.D. of deinking wastes to satisfactory limits during much shorter periods of aeration. Special investigations are also being conducted at the Kalamazoo Station to determine definitely whether aeration and biological action can economically reduce the B.O.D. of deinking wastes to limits acceptable by state water control agencies, and progress is being made on this difficult problem.*

Analysis of Mill Operations

Important information along these lines was obtained among the results

* The results of researches along this line since the presentation of this paper have shown that after the right flora has been built up approximately 85 per cent reduction of the B.O.D. of the deinking wastes can be attained in about 8 hours. Investigations are being continued toward a still further reduction of B.O.D. in a shorter time.

TABLE XIII.—Quantities and Properties of Washer Wastes in Deinking Processes (Cont.)

(d) B.O.D. and Solids Surveys:

Sample	Suspended Solids (%)		Total Solids (%)		pH	B.O.D. (p.p.m.)
	Solids	Ash	Solids	Ash		
Mill E						
White Water	0.089	39	0.143	55	7.70	246
Bleach Water	0.036	50	0.081	59	8.23	167
Second Cylinder Water	0.126	68	0.192	68	8.65	162
Raw Stock	3.96	17	4.7	20	—	—
Raw Stock and Wash Water	1.108	22	1.261	26	9.55	—
Wastes	0.203	69	0.364	58	9.45	450
Product of 1st Cylinder	—	—	7.20	13.3	—	—
Product of Process	—	—	6.88	6.2	—	—
Liquid Drained from Raw Stock	0.575	72	1.197	56	9.98	2150
Raw Stock after Draining	—	—	8.21	15	—	—
Filtrate of Waste	—	—	—	—	—	483
Filtrate of Raw Liquid	—	—	—	—	—	1872
Mill G–C						
Bleach Water	0.080	51	0.155	50	7.42	87
2nd Cylinder	0.079	57	0.156	59	7.74	94
Waste to Sewer from Decker	0.096	66	0.182	58	8.06	119
Filtrate of Decker Waste	—	—	0.089	16.1	—	79
Waste to Sewer from Hollander	0.308	73	0.512	59	8.64	718
Filtrate of Hollander Waste	—	—	0.213	—	—	546
Raw Stock to Hollander Washer	4.1	14.1	4.54	16.3	—	—
Stock from Holland Washer	8.5	10.7	7.56	11.8	—	—
Product of 1st Cylinder	3.43	9.0	3.80	10.4	—	—
Product of Deckers	3.54	7.9	3.63	8.49	—	—
Drain Liquid from Raw Stock	0.297	67	0.626	52.7	9.00	1120
Drained Raw Stock	—	—	9.65	11.4	—	—

[1] Not including excess brown water or excess bleach water.
[2] Equivalent population based on 0.167 lb. 5-day B.O.D. and suspended solids per day.

TABLE XIV.—Aeration of Deinking Waste A–11–S. Comparison of 5-Day B.O.D. after Different Periods of Aeration

Aeration Period (hr.)	5-Day B.O.D. at 20°C. (p.p.m.)						
	I 100% Sewage	II 100% Waste	III 75% Waste 25% Sewage	IV 50% Waste 50% Sewage	V 75% Waste 20% Sewage 5% Activated Sludge	VI 95% Waste 5% Sewage	VII (Tube) 95% Waste 5% Sewage
0	480	420	395	475	425	405	400
5	138	385	315[1]	280[1]	313[1]	325[1]	323[1]
10	53	395	305[1]	205[1]	290[1]	325[1]	305[1]
38.75	19	350	204	134	158	260[1]	264[1]
84.25	25	293	83	46	72	222	188
127.5	—	—	—	—	—	89	81

[1] Final dissolved oxygen after 5 days was less than 1 p.p.m. These data included only to indicate the general trend in reduction of B.O.D.

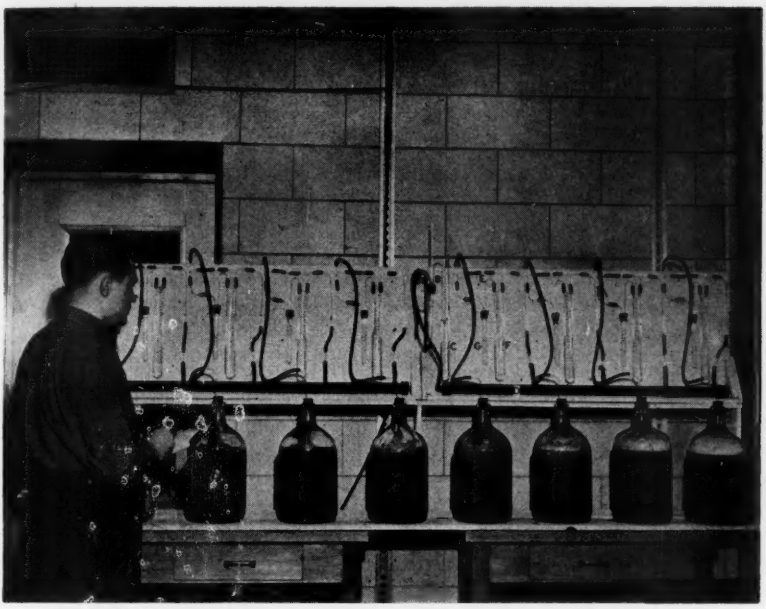


FIGURE 14.—Apparatus for experimental aeration of deinking wastes.

of the analyses of unit operations in three deinking mills in the Kalamazoo district. The calculations of the solids balance surveys showed that the first cylinder accomplished removals of total solids ranging from 76.4 to 80.5 per cent and of B.O.D. material from 82.0 to 84.5 per cent. The advantages of operating the washers at maximum loadings were evident by reduction in one case of wash water volume from 22,000 to 14,020 gal. per 1,000 lb. of raw fiber; an increased yield of fiber of from 1.5 to 2 per cent; and with no marked reduction in the quality of the product.

Independent tests showed that the major portion of the B.O.D. is in the cooking liquor and not in the suspended solids, which confirmed the conclusion drawn from laboratory tests on several deinking wastes. From these and other data it would appear to be possible to remove 72 per cent of the total B.O.D. of the entire plant wastes by segregation of the removals in the first cylinder. The volume of this liquid would be about 17 to 25 per cent of the present total volume of this plant's liquid wastes. Further research on this concentrated waste is in progress.

Deinking Waste Sludge Treatment

Investigations of the sludges settled from deinking wastes were conducted along three main lines: dewatering by (1) vacuum filtration and (2) by centrifuging and (3) the extent of sludge deposits in the Kalamazoo River. The sludges examined contained about 1.5 to 4 per cent solids, and varied widely in volume when precipitated by plain settling or by different chemical coagulants. The weights of the sludges settled after treatment of the deinking wastes by different coagulants, separated from the supernatant liquid and dried at 105° C., ranged from 3.52 to 34.76 lb. per 1,000 gallons

TABLE XV.—Weight of Dried Sludge Obtained from Clarifying Deinking Wastes With Various Chemicals

Chemical Treatment	Lb. of Dried Sludge (105° C.) per 1,000 Gal. of Waste						
	A-9	A-9S	B-3	B-3S	C-2	C-2S	E-3
H_2SO_4	16.72	8.80	8.14	3.52	23.76	4.62	14.08
Alum	24.20	14.30	9.24	4.40	32.78	6.38	13.42
SiO_2+Alum	23.76	14.74	9.24	4.40	33.22	5.94	15.62
Lime	29.70	27.28	8.80	4.40	34.76	9.02	23.54
SiO_2+Lime	27.06	22.66	9.24	3.52	34.54	8.80	24.20
SiO_2+Lime+Alum	28.38	38.94	8.80	4.40	33.00	6.60	22.00

(Table XV). On chemical treatment of the supernatant liquids after plain settling the weights of the sludges were usually much smaller. In the experiments on vacuum filtration and centrifuging the texture and quality of the filter cloths and centrifuge basket liners were found to be important factors. The sludges from plain settling usually dewatered more easily than those obtained by chemical treatments. Vacuum filtration, using a specially designed and constructed filter so that the sludge could be stirred during filtration, produced filter cakes having moisture contents of 44.62 to 50.22 per cent.

Dewatering the sludges by use of a laboratory basket centrifuge gave solid products containing about 44 to 59 per cent moisture. Five-gallon samples of deinking waste sludge were sent to the Sharples Corporation and to the Bird Machine Company for dewatering tests with larger and continuous type centrifuges. The tests with the Sharples super-centrifuge resulted in the accumulation of a fibrous product in the bowl which amounted to 5.5 per cent by volume and contained 42.15 per cent moisture. The Bird Machine Company reported that at extremely low feed rates the solids discharge from their continuous centrifuge contained about 40 per cent solids, that the effluent was not clear, and that the operation was considered not a satisfactory one for a continuous type centrifuge.

If the sludge at any mill had to be dewatered mechanically a continuous rotary vacuum filter might prove to be the best type of machine for the purpose, and it might be necessary, as is often done in sewage disposal practice, to condition the sludge properly before filtration. Where sufficient land of favorable location and character is available the construction of sludge beds might be the most economical method of drying the sludge, allowing surface evaporation and ground seepage to dissipate the excess water in the sludge; or the sludge might be hauled or pumped as a concentrated suspension to impounding reservoirs or lagoons. Further researches on disposal and possible uses for deinking sludge are planned.

Conclusions

In reviewing the results of the researches and investigations carried on by the Fellowships of the National Council for Stream Improvement it is apparent that considerable progress has been made on the very difficult problem of the development of improved methods for treatment and disposal of deinking wastes. The important physical and chemical characteristics of thirty different deinking wastes have been determined analytically, and some of the limits in the properties of this very variable industrial waste have been ascertained.

To reduce objectionable turbidity the quantities of suspended solids which

can be removed by plain settling were found by tests on seventeen deinking wastes to be 70 to 80 per cent in 2 to 4 hours, and about 85 to 90 per cent in 48 hours; in lagoons removal of up to 98 per cent were obtained by long-time sedimentation.

The effects on removal of suspended matter by treating several kinds of deinking wastes, and the supernatant liquids siphoned off after plain settling, with various chemical coagulants and combinations thereof (total of 17) were determined. In the many laboratory investigations on chemical coagulant treatment of deinking wastes, sulfuric acid gave the best results with some wastes, alum or lime with others. Waste pickle liquors gave good results in the few tests made with it. In some tests the use of activated silica or sodium aluminate with lime or alum gave improved results; in other tests no improvement was noted. By selection and application of the correct chemical coagulants to different deinking wastes, followed by a 2-hour settling period, a 98 to 99 per cent reduction in turbidity *may* often be obtained.

The color of the deinking wastes was in general reduced comparatively little by plain sedimentation. The application of chemical coagulants usually, but not always, decreased the color of the supernatant liquid. Ferric chloride produced a good floc, but the color in the supernatant liquid was increased. Alum and alum plus activated silica or sodium aluminate, of all the coagulants tried, gave in general the best results in color removal. However, these combinations would be more expensive than some of the other chemicals if coagulation only was required. Apparently much of the coloring matter in deinking wastes is in solution, or in the condition of very finely divided particles colloidally dispersed in the liquid waste, and hence is not precipitated by most of the common coagulants. Further investigations on removal of color are contemplated.

Researches directed toward development of methods for reducing the B.O.D. of deinking wastes have shown: (1) that the larger portion of the B.O.D. is in the dissolved material in the waste; (2) that plain settling and treatment with different coagulants reduced the B.O.D. only about 8 to 37 per cent; (3) that approximately 70 to 80 per cent of the B.O.D. of the liquid wastes of one entire plant was present in the removals made by the first washer cylinder; also that this B.O.D. was contained in about 17 to 25 per cent of the total volume of this plant's wastes; (4) that aeration of the deinking wastes with and without admixtures of sewage gave reductions of from 50 per cent in 20 to 40 hours aeration up to 70 to 80 per cent in 127.5 hours aeration.

Some of the very recent results obtained indicate the possibility of developing a biochemical aeration process for reducing the B.O.D. within a reasonable time period. Apparently, many laboratory researches on B.O.D. reduction and other phases of this difficult industrial waste disposal problem will have to be carried on and followed by pilot plant investigations before technically and economically satisfactory treatment processes are available.

It is also evident, because of the great variation in properties and composition of deinking waste, that laboratory control of the waste treatment plant will be essential to efficient and economical operation.

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CHARACTERISTICS AND METHODS FOR TREATMENT OF DEINKING WASTES—A DISCUSSION

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A discussion of this paper would be incomplete if it failed to give due recognition of the praiseworthy policies that have been formulated by the National Council for Stream Improvement and the sound planning that underlies the investigation of this problem and others on which the Council is engaged. No less recognition is due the member industries who so generously support this work.

This paper and the investigations leading to its preparation have made a substantial contribution to the progress

of pollution abatement. The data presented illustrate the size of the deinking industry in this country. Based on a production of 400,000 tons of deinked paper pulp in 1944 the processing of this pulp requires over 25,000,000 gal. of water per day and the wastes produced and discharged into the waterways are composed of materials which apparently have a population equivalent of over 800,000.

The paper contains many data which are helpful and enlightening to a pollution abatement agency, even though further investigations and research are planned. It is quite apparent that both volume and composition of deinking wastes vary widely among the different plants, depending upon the kinds of paper and processes used. This is true of all industrial wastes to the extent that each plant almost represents an individual problem. However, it is very helpful to a pollution abatement agency to learn that the industry as a whole produces a certain volume of wastes per ton of product; that the wastes have a composition varying between certain limits; what effect these wastes have upon the receiving stream; the various processes that have been found to produce certain degrees of treatment and the character of effluent discharged from the various treatment processes. The paper presents this information even though a continuation of the research is desirable and contemplated.

The paper interprets the polluting nature of these wastes in terms of B.O.D.—the usual standard. The question is raised as to the accuracy of the 5-day B.O.D. determined upon wastes having a pH of 11 or 12 in a number of instances. The suggestion is therefore advanced that future investigations include oxygen consumed determinations, requiring less time to carry out, and which might be correlated to the B.O.D. values.

The authors do not state the method used for determining suspended solids, and it is assumed that the standard method was used. The paper industry apparently favors a more simple and less time-consuming method. The correlation of the figures from various determinations would be valuable in interpretation of the results.

It is interesting to note the distribution of B.O.D. in these wastes—70 to 80 per cent is contained in the dissolved material and only 20 to 35 per cent in the settleable solids. Furthermore, most of the B.O.D. is contained in from 17 to 25 per cent of the total volume of wastes produced. Such information is useful in deciding upon the size of treatment plant and the degree of treatment required to maintain satisfactory conditions in the receiving stream.

The paper indicates that lagooning of these wastes has a definite application at plants where B.O.D. reduction is not significant and where a large area of otherwise useless land is available, since suspended solids can be thus reduced from 70 to 98 per cent.

The paper includes discussions of various treatment processes such as dilution, heating, filtration on mechanical filters, centrifuging, the use of carbon dioxide, etc., bioaeration, and clarification with chemical coagulants. The results indicate that some of the processes are not practical while others appear to offer some promise under certain conditions.

Conditions in Connecticut, and undoubtedly in many other States, indicate that treatment with chemical coagulants will have the widest application. The first part of this process is not difficult to operate. The kinds of chemicals and the amounts required will have to be determined upon the wastes produced by the individual industry. The most difficult part of this process, which also applies to the chemical treatment of all types of industrial wastes, is the handling and disposal of large volumes of sludge. Here again many industrial plants do

not have sufficient areas for sludge lagoons or sludge drying beds. This paper leaves the very encouraging impression that mechanical dewatering equipment may offer the solution to this large and important problem. It is hoped that further research will develop such equipment for practical use at a reasonable cost.

A limited investigation of the treatment of deinking wastes has been made by the Connecticut State Water Commission through its research laboratory at Wesleyan University, Middletown, Conn. It must be pointed out that this investigation was limited by the fact that the deinking plant, after some preliminary operation and production, was forced to close due to difficulties of operation under war conditions. Furthermore, it was necessary to require a rather high degree of treatment of the wastes because of their discharge into a cove which was surrounded by attractive residences.

The material to be deinked consisted largely of heavily sized magazine paper. The deinking process included the use of soda ash, sodium silicate and certain fatty acids. The two principal wastes were those from the so-called thickener and the more dilute washer wastes. The average analyses of these wastes were:

	Thickener Wastes	Washer Wastes
pH	10.2	9.4
Total alkalinity (p.p.m.)	900	350
Total solids (p.p.m.)	3,800	725
Volatile solids (p.p.m.)	1,230	325
Fixed solids (p.p.m.)	2,575	400
Suspended solids (p.p.m.)	2,900	410
Oxygen consumed (p.p.m.)	730	245

Treatment with chemical coagulants was decided upon as the most practical. A number of coagulants were investigated but for these wastes it was concluded that lime and alum produced the best results. The major part of the investigation was concerned with the treatment of the more concentrated thickener wastes. It was found that the addition of 4 lb. of lime and 4 lb. of alum per 1,000 gal. of wastes produced fairly good results. However, the supernatant liquor remained slightly turbid after 2 hours of settling, and the reduction of O.C. was about 75 per cent. Further investigation disclosed the value of diluting the wastes prior to the addition of chemicals. It was found that if these wastes were diluted 1:1 with tap water and 0.5 lb. to 1 lb. of lime and 1.5 lb. to 2 lb. of alum added, the supernatant after 2 hours settling showed a reduction in suspended solids of 99 per cent and in O.C. of about 95 per cent. It was further found advantageous to allow a 10- to 20-min. period after the addition of lime before the alum was added in order to produce a clear supernatant. The sludge produced amounted to 10 to 15 per cent of the original volume, and the pH of the supernatant was about 8.

It was tentatively planned to dispose of the sludge on drying beds as a temporary measure pending further investigation of other dewatering methods.

The paper under discussion represents a valuable contribution toward pollution abatement and illustrates what can be done when industries of similar nature combine into an association for the purpose of solving their pollution problems, with the further compensating advantage of better and more efficient production. This latter advantage appears generally to follow, or results simultaneously with industrial pollution abatement measures.

PROBLEMS IN THE APPLICATION OF THE BIO-CHEMICAL OXYGEN DEMAND TEST TO PULP AND PAPER WASTES *

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With the widespread application of the B.O.D. test to a great variety of industrial waste waters, it has been subjected to considerable criticism due to the frequency of inconsistent results. Such criticism is quite understandable and arises from a number of factors. Some criticisms are justifiable; others are not.

In some cases too great a degree of accuracy is anticipated from a biological test by those constantly employed in chemical work. Any test subject to 10 per cent error is frequently viewed askance by industrial chemists. The requirement of a sufficient number of determinations to allow safe conclusions is at times not adhered to, and too often improper sampling, handling and technique account for highly variable results. Blind application of the method as described in the eighth edition of "Standard Methods" can also lead to difficulties, since a knowledge of the factors involved in the determination and the characteristics of the waste being tested are necessary for the selection of a suitable modification.

Instances where criticism is justified also exist. The test when used in the best of its present forms is not without shortcomings and for some few wastes, particularly those having high chemical demands, may never prove satisfactory.

The answer is in further investigation and not the discard of a test for which there is no adequate alternate. The writer can recall when the B.O.D. test for sanitary sewage was not universally accepted because of inherent limitations. However, research has now made this a major criterion for measurement of the degree of sewage treatment and stream loading.

If applied to industrial wastes with a knowledge of the requirements of the test and of the character of the waste, together with the selection of a suitable technique, good results can be obtained with most wastes. This has been evidenced repeatedly by the checks obtained between stream survey data and computations made from loadings based on B.O.D. tests. It is also obvious that the test is satisfactory for many wastes by comparison of rates obtained for various wastes with that of sewage, which may be considered as containing all the ingredients required by bacteria to operate at maximum efficiency and thus to produce close to maximum rates.

Factors Affecting B.O.D. of Pulp and Paper Wastes

Since production of pulps, papers and paperboards produces wastes of widely varying composition and characteristics, it is quite natural that the measurement of the oxygen demand of some of them would present problems. This is particularly the case since most of these wastes are more or less deficient in nitrogen and phosphorus, which are so necessary if aerobic decomposition is to proceed at a normal rate, and some contain chemicals which act as depressants or are actually

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TABLE I.— Comparison of Supplemented Dilution Water with River Water in Determination of B.O.D. of Pulp and Paper Wastes.

Sample	5-Day B.O.D. (p.p.m.)			
	Raw		Effluent	
	River Water	Supplemented Water	River Water	Supplemented Water
Howard Process effluent diluted with sewage:				
1	665	665	170	185
2	700	670	210	190
3	740	710	130	130
4	1,299	1,166	340	325
5	1,248	1,182	330	255
6	1,117	1,017	225	210
7	1,682	1,782	420	420
8	1,598	1,482	515	470
9	1,749	1,552	—	—
Raw sulfite liquor diluted with river water:				
10	670	710	465	590
11	650	790	445	530
12	660	760	440	530
13	932	1,066	716	766
14	899	999	750	882
15	999	1,282	682	849
16	999	949	513	538
17	932	983	550	468
18	949	899	490	500
19	1,299	1,599	810	790
20	1,299	1,249	790	770
21	1,332	1,299	820	680
22	1,265	1,382	390	450
23	1,399	1,365	400	470
24	1,283	1,332	340	390
25	1,600	1,657	675	700
26	1,575	1,725	—	—
27	1,400	1,275	638	650
Total	30,940	31,547	12,254	12,738
Per Cent	100	102	100	104

toxic. The presence in others of chemical oxygen absorbers such as bisulfites, and of wood sugars capable under some conditions, as pointed out by Martin (1), of promoting the decomposition of even resistant lignins further complicates the picture.

Prior to the investigations of Lea and Nichols (2), the B.O.D. test as applied to pulping effluents in particular meant little when bicarbonate dilution water was employed. Tests using river waters gave considerably higher results, checking more closely observed stream conditions. The use by Lea and Nichols of a water supplemented with nitrogen and phosphorus to a degree that the proper ratios of these elements to carbon were maintained produced oxygen demand figures for sulfite waste liquor almost 100 per cent higher than did bicarbonate water. As examination of Table I will reveal, the supplemented water recommended by these workers produced demand figures very close to those obtained in river water for diluted sulfite waste liquor (raw), after lignin removal and after biological oxidation which removes most of the simple sugars.

The importance of the Lea and Nichols findings to the accurate determination of B.O.D. for a number of the more important pulp and paper wastes is illustrated in Table II, in which the daily oxygen utilization in terms of percentage of the 5-day demand is compared to that of sewage according to Theriault (5). These determinations were made using neutralized waste samples and supplemented seeded dilution water, and represent the average of a number of determinations.

It will be noted that paperboard waste, deinking washer waste, flax pulping waste and kraft waste are all close to the sewage figures. Strawboard waste and sulfite liquor deviate somewhat. In the case of the former data was somewhat limited, and when more figures are available it will probably be found to simulate more closely the sewage figures. The slower rate observed for sulfite liquor may be due to a number of variables, some of which are known. The presence of sulfur dioxide slowly liberated from compounds in which it is loosely bound

TABLE II. Per Cent of 5-Day B.O.D. Satisfied

Days	Sanitary Sewage	Paper Board Waste	Deinking Washer Waste	Combined Strawboard Waste	Sulfite Waste Liquor	Flax Pulping Waste	Jute Pulping Waste	Combined Kraft Mill Waste
1	30	31	30	22	23	31	3	32
2	54	56	62	69	41	59	19	67
3	73	74	78	82	58	79	63	76
4	88	89	91	86	75	91	95	90
5	100	100	100	100	100	100	100	100

has been shown to have a depressing effect on aerobic decomposition.

Sawyer (6) has demonstrated variations dependent upon the degree of dilution in sulfite liquor B.O.D. tests, and recently Tyler (7) has shown that the present seeding technique can be inadequate under some conditions. In addition, Weston (8) has demonstrated the stimulative and adverse effect of the presence or absence and relative concentrations of various organic compounds which may or may not be present under the conditions of these tests or may vary in concentration throughout them.

Jute pulping waste was the only one of those studied which deviated markedly from sewage, exhibiting a decided lag of unknown cause. Waste samples were neutralized prior to running the tests and they were not believed to contain toxic compounds. It is possible that the organic matter present is of a resistant nature since the raw material pulped was previously processed.

Despite the limitations pointed out above the overall picture is decidedly encouraging since most of the wastes tested either follow the sewage rate closely or do not deviate widely enough to discredit the test if it is run by modern methods. The figures are decidedly encouraging when it is realized that not long ago the B.O.D. test was considered unsuitable for several of these wastes, and had been replaced by the oxygen consumed determination. This was particularly true of deinking washer wastes for which B.O.D. figures obtained by the present method exceeded former data as much as 200 per cent, and in some instances explained stream conditions previously unaccounted for on the basis of determined loadings. Thus it is felt that the Lea and Nichols studies have brought the B.O.D. test to a point where it can be considered satisfactory for most pulp, paper and paperboard waste. Despite these advances, problems still remain.

Fiber Oxidation

One of the major questions regarding pulp and paper waste which is as yet unsolved is the rate of oxidation of fiber. Some have held that fiber retained in suspension in a stream is but slowly decomposed and adds little to the oxygen demand. Others cite instances where fiber discharge in white waters appears to be the major factor in high oxygen depletion. Phelps (1) suggests that these diverse observations may be due to the fact that in some streams cellulose is decomposed and others not, depending upon the relative numbers of cellulose decomposing organisms present in the water.

Experimental work at Rutgers University dealing with the B.O.D. rates of paperboard mill waste before and after fiber removal yielded variable results. Pounds of 5-day B.O.D. per pound of volatile suspended solids were found to vary from 0.015 to 0.29, indicating wide variability in the rate of fiber decomposition over this time interval. In all cases sewage seeding was practiced and an excess of avail-

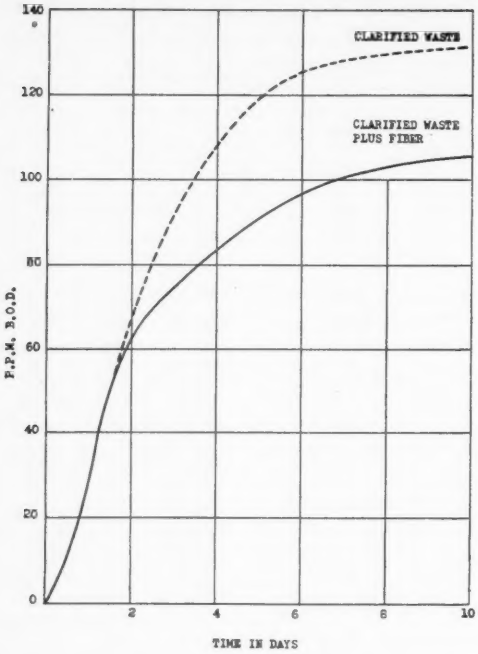

FIGURE 1.—Effect of added cellulose fiber on B.O.D. rate of clarified board mill white water.

able nitrogen and phosphorus was present as well as considerable heterogeneous dissolved organic matter normally found in such wastes. Indications were that on longer periods of incubation fiber decomposition became more uniform. Results were not sufficiently reproducible, however, to be conclusive. B.O.D. tests in which cellulose fiber was added to clarified waste showed lower 10-day rate curves than those to which no cellulose was added, as illustrated in Figure 1. The only explanation forthcoming to explain this phenomenon is the possibility that some of the readily available dissolved organic matter becomes absorbed by the fiber in such a manner that it is not easily available to the microorganisms capable of oxidizing it.

Attempts to obtain rates over longer periods of time produced results as shown in Figures 2 and 3. It appears from Figure 1 that the fiber decomposes rapidly after 10 days. It is likely, however, that the sharp rise in the latter portion of the curve in Figure 3 is due to vitrification of the ammonia present rather than cellulose decomposition. This can be checked in a number of ways, and further study will undoubtedly supply the answer. In event that vitrification is the cause, the matter of obtaining an adequate method of determining the oxygen utilization over long periods of time of fiber in white waters will have to be evolved. If the rapid rise in oxygen utilization after 10 days is due to fiber, however, the inadequacy of present seeding methods is indicated, and Phelps' theory (1) of the reaction of fiber in streams would appear sound.

An effort was made to determine the oxidation rate of fiber of various types unassociated with other wastes, but

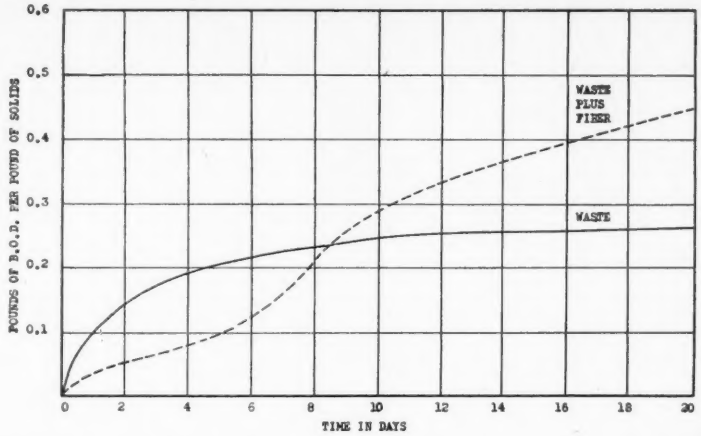

FIGURE 2.—Effect of added cellulose fiber on the oxygen demand of clarified board mill white water.

supplying the required nutrients in the form of nitrogen and phosphorus salts. Results to date have been decidedly variable despite the fact that special techniques such as periodic agitation of the bottles to keep the fiber in suspension were resorted to. As shown in Table 3, however, most of the common types of pulp exhibited a distinct oxygen demand in 5 days. The figures presented also indicate that the observed demand is influenced to a decided degree by concentration. The most puzzling result is the variation between the various types of pulp since the oxygen demand in no way follows

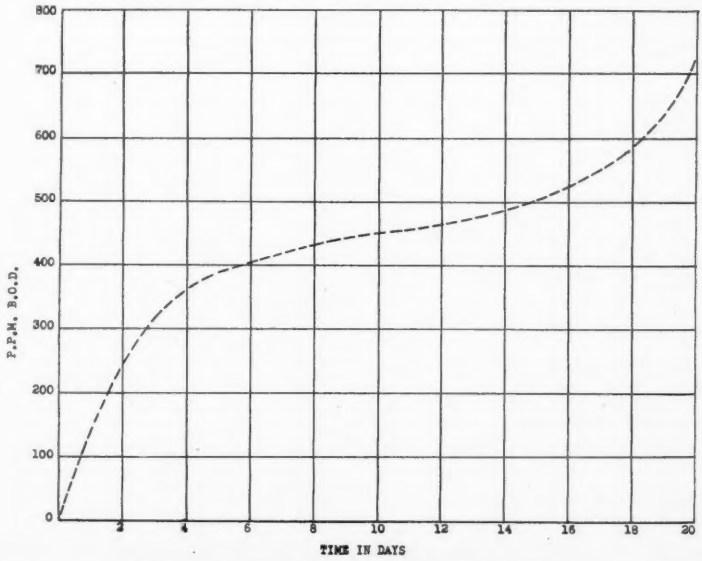

FIGURE 3.—B.O.D. rate of raw board mill waste.

TABLE III.—Oxygen Utilized in Five Days Per Gram of Pulp

Pulp Concentration (gm./l.)	Groundwood Pulp	Alpha Cellulose	Semi-Chemical Pulp	Unbleached Sulfite Pulp	Unbleached Kraft Pulp	Bleached Kraft Pulp
0.66	80	60	60	100	35	165
1.36	58	63	50	78	30	120
1.98	53	42	58	55	35	68
2.64	56	44	52	39	49	73
3.30	48	15	50	—	43	68
6.60	—	26	35	32	33	—

the cellulose content, and the substances other than cellulose present are believed to be highly resistant as the pulps were subjected to long washing prior to use. Groundwood, semi-chemical and unbleached kraft pulps containing about 35, 45 and 55 per cent of alpha cellulose oxidized to about the same, or a lesser degree, than the alpha pulp containing over 99 per cent. Unbleached sulfite containing about 70 per cent alpha cellulose appeared to oxidize faster than the alpha in lower concentrations but at about the same rate at higher concentrations. Bleached kraft of about the same alpha cellulose content as the unbleached sulfite exhibited higher oxidation rates than any of the other pulps at all the concentrations studied. From the magnitude of the figures it appears that the oxidation rate of all types of fiber in 5 days is relatively low under stream conditions. However, the question of the type of seed employed still enters the picture and projected tests in which the sewage seed will be replaced with an extract from actively decomposing cellulose may alter the picture.

Conclusions

The data presented serve to illustrate a problem in B.O.D. application to a specific type of industrial waste not dissimilar to a number of others and the methods of investigation employed in approaching a solution.

It is concluded that the B.O.D. test is far from useless in pulp, paper and paperboard waste studies. The research of those referred to in this paper, as well as that of Lea and Nichols, Sawyer, Hatfield, Moore, Ruehhoft, Heukelekian, Hodge, Bloodgood and others, is gradually overcoming the difficulties for a wide variety of wastes and continued research will, in time, solve most of the problems involved in the application of this important test to most industrial wastes. While the B.O.D. determination may in time be replaced in research laboratories for certain concentrated wastes with respirometer tests, there is little likelihood of its being abandoned. Chemical tests have been looked to repeatedly because of their rapidity and reproducibility to replace the B.O.D. However there is no reason to believe that any test can be found which is capable of measuring the quantity of respiratory oxygen utilized by microorganisms acting on the constituents of a waste under natural conditions, and in a given length of time, by determining organic matter oxidizable under specific chemical and physical conditions. Since the B.O.D. test can most closely simulate stream conditions, it will likely remain the best index of actual conditions.

Acknowledgments

The data presented herein were assembled from research reports of National Council for Stream Improvement projects at Purdue University, Mellon Institute, Rutgers University, University of Michigan, the Institute

of Paper Chemistry and Kalamazoo College, as well as the research laboratories of several industries. The writer is appreciative of the cooperation rendered by the directors of these laboratories in making the material forming the basis of this paper available to him.

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PROBLEMS IN THE APPLICATION OF THE BIOCHEMICAL OXYGEN DEMAND TEST IN PULP AND PAPER WASTES—A DISCUSSION

By Roy F. Weston

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Dr. Gehm's paper presents thoughts and data of considerable interest and of value in furthering an understanding of the B.O.D. determination and its application. Time will not permit a discussion of both the general and technical aspects of the paper so the writer will confine his remarks to the general thoughts of the paper pertaining to the standing of the B.O.D. determination in industrial waste disposal circles, the place that the B.O.D. determination holds in pollution abatement work, the replacement of the determination by chemical oxidation methods, and trends in opinions and investigations at the Waste Control Laboratory of the Atlantic Refining Company.

There are a number of influential men within and outside the sanitary science profession who hold the B.O.D. determination in such poor regard that they are ready to endeavor to discredit it and to discard it as a measure of the polluting characteristics of an industrial waste. This attitude is brought about by the erratic and frequently unreasonable results obtained using past and for that matter current dilution waters and techniques. At the 1946 conference of the Pennsylvania Sewage Works Association the writer presented a review of the characteristics of the B.O.D. determination, discussions of the 18 or more factors that may influence B.O.D. results and a summary of considerable research work on the effect of the mineral and organic contents of dilution waters on B.O.D. values. This review and a summary of past and current research work will be published within the year as a monograph of the Waste Control Laboratory of the Atlantic Refining Company. Of the 18 or more variables

influencing B.O.D. values, the writer believes that all of those of major importance can be adequately controlled to give reproducible results that will be typical of those obtained in natural waters.

The writer agrees with Dr. Gehm that there is no adequate alternate, at this date, for the B.O.D. determination as a yardstick of the biochemical oxygen consuming characteristics of a waste as could be expected under natural conditions. The reasons for this belief may be found in experimental data and in the following theoretical statement of Dr. Phelps (2): "It (*i.e.* B.O.D.) is not at all related to the complete oxygen requirements in chemical combustion but is determined wholly by the availability of the material as a bacterial food and by the amount of oxygen utilized by the bacteria during its oxidation." Current dilution waters and determination techniques may not produce results typical of natural waters but fundamentally the B.O.D. determination measures a characteristic of a waste that is of great importance in pollution abatement work. Research will provide the data essential to the proper standardization of the method.

Dr. Gehm presented data illustrating the influence of the presence of cellulose fiber on the oxidation of paper mill wastes. In Figures 1 and 2 are data showing the influence of the presence of activated carbon on the B.O.D. of sewage (3). The graph on the right shows that the activated carbon adsorbed oxidizable material from solution and retained this material in such a manner that it was not available for biochemical oxidation in 5 days at 20° C. The reductions in B.O.D. follow Freundlich's adsorption isotherm equation. Figure 1 shows that in this case the activated carbon made oxidizable material unavailable for biochemical oxidation for at least 20 days. Thus food was present but not available for biochemical oxidation.

In the past year, a chemical method for estimating the total oxygen demand of a waste using iodate was presented by Johnson, Halverson and Tsuchiya (1). The writer has found this method to be accurate for C.P. chemicals, and to be highly reproducible on both C.P. chemicals and petroleum refinery wastes. The results of two determinations on each of 23 different waste waters, using different quantities of sample, indicate that the

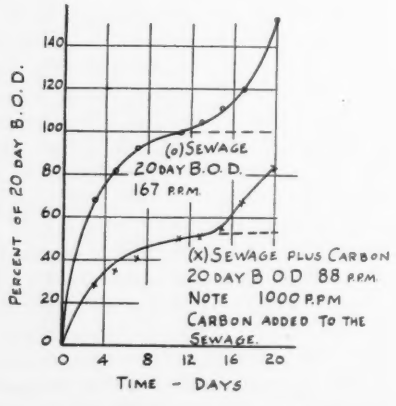

FIGURE 1.—The influence of the presence of activated carbon on the oxidation of domestic sewage.

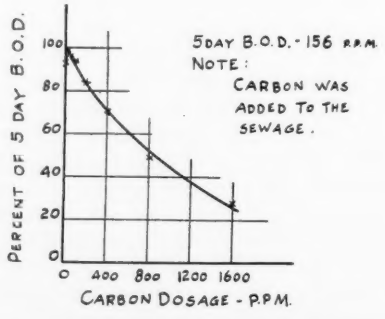

FIGURE 2.—The influence of the presence of variable activated carbon concentrations on the oxidation of domestic sewage.

average deviation from the mean was 3.1 per cent. However, 50 per cent of the results have a 1.8 per cent or smaller deviation from the mean and the mode of the data was at 0.9 per cent deviation from the mean. These data indicate excellent reproducibility.

The relationship between B.O.D. as determined using Theriault-Nichols dilution water and the chemical oxygen demand for various materials is shown in Table I. These data provided experimental proof of the theoretical fact that there is no definite relationship between the chemical oxygen demand and the biochemical oxygen demand for all materials or for plant wastes of variable quality. However, wastes of reasonably constant composition, such as the waste caustic from a single process, may show a relatively consistent correlation. It is interesting to note that the ratios given are, in general, considerably lower than the theoretical ratio of 5-day B.O.D. to ultimate B.O.D. of 0.68 for domestic sewage. The ratio between B.O.D. and C.O.D. provides an indication as to the availability of oxidizable materials for biochemical oxidation. It is the writer's belief that both determinations are essential to a complete understanding of an industrial waste disposal problem.

Current research has revealed some interesting relationships. The results of three recent runs are shown in Table II. These data are presented because of their important implications. The data indicate a potential high degree of reproducibility for the writer's Modified U. S. Mean dilution water, and good reproducibility for the Theriault-Nichols dilution water. The influence of seeding material is most pronounced. A change in seeding material from Schuylkill River water [1] to soil extract [2] caused a 24 per cent increase in the B.O.D. of waste caustic using Theriault-Nichols dilution water. The change in seeding material from soil extract to Schuylkill River water caused about a 28 per cent decrease in 40 per cent of the samples (B.O.D. of $66{,}700 \pm 1{,}260$) and excellent reproducibility in 60 per cent of the samples (B.O.D. of 93,200

[1] 1 ml. per liter of fresh Schuylkill River water.

[2] 1 ml. per liter of filtered soil extract made by using 1 gm. of soil per liter.

TABLE I.—The Relation Between Total Chemical Oxygen Demand and Biochemical Oxygen Demand for Various Chemicals and Wastes

Substance	Number of Samples	Biochemical Oxygen Demand (p.p.m.)	Total Chemical Oxygen Demand (p.p.m.)	Mean	Ratio B.O.D. to C.O.D. (Standard Deviation)	Coefficient of Variation
Dextrose (0.1% solution)	1	563	1,063	0.53	—	—
Phenol (0.1% solution)	1	1,475	2,380	0.62	—	—
Glutamic acid (0.1% solution)	1	567	979	0.58	—	—
Peptone (0.1% solution)	1	538	1,117	0.48	—	—
Yeast extract (0.1% solution)	1	440	943	0.47	—	—
Tanning liquor	1	3,070	14,820	0.21	—	—
Sulfite liquor	1	23,870	120,150	0.20	—	—
Petroleum refinery waste waters:						
Waste caustic	14	8,180–110,600	23,580–390,000	0.316	0.056	0.177
Distillation condensate waters	18	68–7,070	214–16,260	0.312	0.159	0.510
Oil treating area waste waters	10	86–272	216–3,167	0.214	0.183	0.855

Note: All B.O.D. determinations are 5-day values at 20° C., using Theriault-Nichols Dilution water. The B.O.D. and C.O.D. values given for single samples are the average of not less than two determinations. The C.O.D. is the oxygen demand from iodate (1).

TABLE II.—A Comparison of the Biochemical Oxygen Demand of Waste Caustic Using Different Dilution Waters

Run No.	Dilution Water	Seed Material	Number of Different Dilutions	Number of Samples	Biochemical Oxygen Demand		
					Mean (p.p.m.)	Standard[6] Deviation (p.p.m.) S	Coefficient of Variation C_v
1[3]	Modified U.S. Mean[1]	Soil Extract	1	20	93,300	2,290	0.025
	Theriault-Nichols	Schuylkill R.	1	20	73,700	2,600	0.035
2[3]	Modified U.S. Mean[1]	Schuylkill R.	1	20	82,500	12,780[5]	—
	Theriault-Nichols	Schuylkill R.	1	20	70,600	5,510	0.078
3[4]	Modified U.S. Mean[1]	Soil Extract	3	12	93,200	3,370	0.036
	Theriault-Nichols	Soil Extract	3	12	89,600	5,000	0.056
	Schuylkill River[2]	Soil Extract	3	12	85,400	8,420	0.099

Note:
[1] U. S. Mean Dilution water plus peptone and vitamins.
[2] Schuylkill River water aerated seven days and filtered.
[3] Dilutions made outside the B.O.D. bottle.
[4] Dilutions made inside the B.O.D. bottle.
[5] Two definite levels of B.O.D. occurred in this case. One level was at about 93,000 p.p.m. and the other level was at about 67,000 p.p.m. The mean deviation is given instead of the standard deviation.
[6] Standard deviation for small samples.

$\pm$ 3,310) using Modified U. S. Mean water.

The variations due to seeding indicate that the modified U. S. Mean water is probably still lacking some trace ingredient essential to positive reproducibility but that its composition is superior to that of the Theriault-Nichols dilution water for waste caustic. Current research plans may provide the information essential to bridge this gap.

The writer agrees with Dr. Gehm that the B.O.D. determination can most closely simulate stream conditions of any known test method. Improvements in dilution water composition and seeding technics may change the status of the determination from that of an over-popularized relatively unreliable indicator to that of a reliable reproducible analytical method. Until that day and possibly later both B.O.D. and C.O.D. data should be obtained on all industrial wastes to assure an adequate knowledge of their characteristics.

The writer wishes to acknowledge the work of Messrs. Joseph G. Demann, Biologist, and Harry Turnbull, Chemist, of the Waste Control Laboratory staff in obtaining the data presented herein, and the cooperation and criticisms of Mr. W. B. Hart, in charge of Pollution Abatement Activities, The Atlantic Refining Company.

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USE OF DIRECT METHOD OF OXYGEN UTILIZATION IN WASTE TREATMENT STUDIES *

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The dilution method of determining B.O.D. is well established and is very useful in estimating the strength of sewage and the efficiency of treatment. It also is used successfully in forecasting the effect of effluents on the deoxygenation of the stream. It has, however, certain inherent limitations. These arise from the low solubility of oxygen in water and the consequent extreme dilutions necessary to maintain dissolved oxygen. It is generally accepted that in the case of sewage the dilution has little influence on the oxygen demand. Not only do various dilutions check closely with one another, but the oxygen demand of sewage determined by the dilution method and the direct method (without dilution) is in satisfactory agreement. In other words, the deoxygenation rate of sewage is independent of the dilution or concentration.

There have been indications, however, that such is not the case with certain industrial wastes. The use of mineralized dilution water fortified with nitrogen and phosphorus, the correction of the pH value, and proper seeding do not always give consistent values with such wastes. The B.O.D. sometimes varies with the dilution, usually being greater with higher dilutions, and therefore has little meaning unless the dilution used is specified. Even when uniform results are obtained with various dilutions there is no assurance that toxic materials may not be present. It may only indicate that due to the high dilutions employed as a result of the high B.O.D., the toxic effects are overcome and that at a lower dilution the demand exerted may be lower. The dilution method cannot be used to determine the inhibiting effects over a wide range of dilutions. Furthermore, the B.O.D. exerted in a treatment plant or in a stream may be entirely different unless the degree of dilution happens to correspond to the dilution used in the B.O.D. determination.

Industrial wastes are extremely variable in their chemical composition, in the concentrations of the various ingredients, and in their effect on deoxygenation. A tentative classification would include the following categories in respect to their effect on the deoxygenation rates:

1. Wastes with no B.O.D.:

(a) No toxic property at any concentrations.

(b) Toxic effect at high, no effect at medium, and a possible stimulating effect at low concentrations.

2. Wastes with B.O.D.:

(a) No toxic property at any concentrations.

(b) Toxic effect at high, no effect at medium, and a possible stimulating effect at low concentrations.

In the direct method of oxygen utilization, the quantity of oxygen does not become a limiting factor, and high concentrations of even the strongest waste can be used in the determination. It should, therefore, be possible to study over a wide range of concentrations the effect of any industrial waste and determine whether the waste

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in general or any specific ingredient of it falls in one or the other of the above categories. The information obtained by this means should be valuable in forecasting whether a doubtful waste is amenable to biological treatment, and to what degree it has to be diluted before it can be made amenable to treatment.

It is the purpose of this paper to illustrate some of these uses of the direct oxygen method in the study of industrial wastes. Not all the possible ramifications can, of course, be discussed in this paper. A detailed study of a single industrial waste is not attempted, but rather a rapid survey is given of a number of wastes to indicate the possibilities.

Method

There are two procedures available in studying the deoxygenation effects of industrial wastes. (1) In some cases the waste in question or a specific ingredient of it is best studied by adding it to a substrate. The substrates can be sewage, activated sludge, or humus sludge. The selection of the specific substrate will depend on whether the effect to be studied is one of general application or whether the effect on a specific type of treatment is desired. The substrate which is selected will furnish the nutrients, the organisms, and the necessary dilution. (2) In some other cases it may be more desirable to use the waste itself as a substrate after seeding it with sewage, soil, adapted seed, or activated sludge. In either case a proper adjustment of the pH value to the zone of optimum biological activity is necessary, for beyond this zone the controlling factor will be that of the obvious pH effect. In certain cases where the nutrient balance of the waste is improper, it may be necessary to supplement the substrate with nitrogen and phosphorus. This is true especially when the waste itself is used as a substrate, and sometimes even when sewage is used as a substrate, depending on the dilution of the waste and its nutrient deficiency.

The observation period should be long enough to allow for possible initial lag or retardation, including a peak rate of oxygen utilization, which is usually followed by a decreasing rate.

If it is desired to study the effect of adaption of the seed material to the waste, a part of the material after treatment may be used as seed for the treatment of repeated doses of the waste, the oxygen utilization rate being determined each time.

Results

Ferric Chloride

The effect of a limited range of concentrations of ferric chloride on the oxygen utilization of sewage was determined. The primary purpose was to determine whether ferric chloride dosages used in the coagulation of sewage and in the Guggenheim process have a stimulating or a retarding effect on the oxygen utilization rate. In order to eliminate the effect of ferric chloride on the pH value, the alkalinity of the sewage was increased by the addition of sodium bicarbonate in sufficient quantity to poise the pH value at or about 7.0.

The results are given in Table I. It is difficult to find any indication of stimulation, except with the addition of 10 p.p.m. of ferric chloride during the first day, which gave an oxygen utilization higher than the control. Since, however, all the other values obtained with the various concentrations of ferric chloride are lower than the control, this single value can be dismissed. Actually the oxygen utilization is lowered by the addition of ferric chloride.

Similar observations were made earlier in sludge digestion, where gas production is lowered by ferric chlo-

TABLE I.—Effect of Ferric Chloride on the Oxygen Utilization Rate of Sewage. (Cumulative oxygen utilized in mg. per liter)

	1	2	3	4	5	6	7
Ferric chloride (p.p.m.)	0	5	10	25	50	100	200
Days							
1	20.9	20.8	25.7	15.2	13.1	14.8	15.9
2	62.5	56.5	57.3	51.5	43.6	44.2	38.3
3	124.1	101.8	106.7	108.1	110.5	105.2	99.6
4	200.0	171.6	178.7	179.4	183.1	168.3	174.1
6	215.0	187.6	199.3	189.7	193.3	184.1	184.5
8	300.9	261.5	269.5	275.7	269.5	257.5	256.4
pH initial	8.0	7.8	7.8	7.6	7.5	7.2	7.1
pH final	7.3	7.1	7.1	7.1	7.0	7.1	7.2

ride. A stabilization of organic matter with consequent inability of micro-organisms to utilize it seems to be brought about by ferric chloride.

Phenol

The effect of phenol on bacteria has been studied extensively and methods of treating phenolic wastes have been developed. A study was therefore made on the effect of phenol on the oxygen utilization of sewage.

The results given in Table II indicate that all traces of phenol added in concentrations of 500 p.p.m. or less had disappeared in 10 days. The phenols were determined by Baylis' modification of Gibbs' method, which is sensitive in parts per billion. When 1,000 p.p.m. of phenol was added there was a residual of 285 p.p.m. after 15 days. The oxidation of phenol resulted in the lowering of the pH value, the magnitude of the depression increasing with higher concentrations. A minimum pH of 5.6 was attained with 1,000 p.p.m. phenol. It is also of interest to note that the ammonia nitrogen content of the sewage was lowered, but except with the addition of 1,000 p.p.m. phenol it was not low enough to become a limiting factor. The depression in the ammonia nitrogen level in this case was from 17 p.p.m. to 1 p.p.m.

The amount of oxygen utilized daily is given in Figure 1. The effect of the addition of 25 p.p.m. phenol was to increase the level of oxygen utilization during the first day. The oxygen utilization with 50 p.p.m. phenol was lower than with 25 p.p.m. during the first day, but higher than the control. The amounts of oxygen utilized on the 2nd, 3rd, 4th, 5th days were, however, higher than with the 25 p.p.m. addition. With 100 p.p.m. the peak of utilization occurred on the 2nd day instead of the first, and the level was higher than with the preceding concentrations. With 250 p.p.m. the peak was reached on the 3rd day. With 500

TABLE II.—Destruction of Phenol and Changes in pH Value and NH_3-N by Addition of Various Concentrations of Phenol to Sewage

	1	2	3	4	5	6[1]	7[1]
Phenol added (p.p.m.)	0	25	50	100	250	500	1,000
Phenol remaining (p.p.m.)	0	0	0	0	0	0	285
pH initial	7.5	7.5	7.5	7.5	7.5	9.5	7.5
pH final	6.7	6.3	6.3	6.1	6.0	5.7	5.6
NH_3-N at end (p.p.m.)	17.0	17.0	16.0	12.0	13.0	13.0	1.2

[1] Incubation period 15 days; all others 10 days.

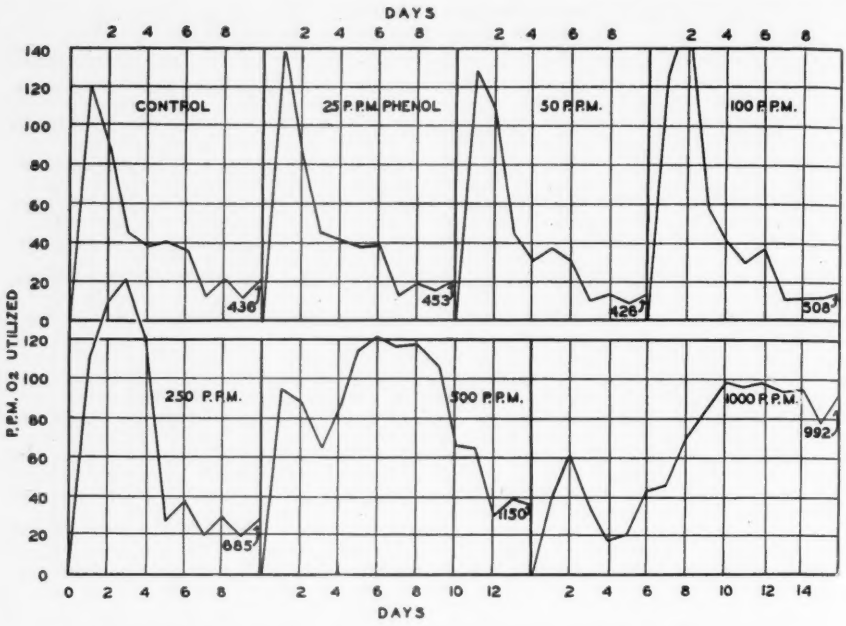

FIGURE 1.—Effect of phenol on oxygen utilization rate of sewage.

p.p.m. the peak occurred on the 5th day with lower rate of utilization. It is of interest to note the break in the curve on the 3rd day, which indicated possibly a shift in the flora and the establishment of phenol-tolerant organisms. A break in the curve occurred also with 1,000 p.p.m. phenol on the 4th day. Thereafter, the amounts utilized increased gradually. There was no well-defined peak, nor had the amount decreased at the end of 15 days, bearing out the fact that phenol was not completely consumed.

It appears from these results that phenol up to 50 p.p.m. has no retarding influence on the oxygen utilization and that the oxidation time is not affected. One hundred p.p.m. phenol increases somewhat the oxidation time but has no effect on the amount of oxygen utilized. When the concentration is increased further, retarding effects are noticed, as evidenced by lower amounts utilized and increasing time required for oxidation. It is also apparent that even 1,000 p.p.m. phenol can be oxidized provided a sufficiently long time is allowed.

Chloroform

In contrast with phenol, it is of interest to compare the limiting concentration of chloroform. This material is sometimes present in wastes such as penicillin spent broth, and it is necessary, therefore, to know the concentration of chloroform that can be tolerated before a successful biological treatment process for this waste can be developed.

The results of an experiment in which various amounts of chloroform were added to sewage are given in Table III. One c.c. per liter of chloroform retarded the oxygen utilization the first day, but thereafter the amounts were higher than in the control. The total amount of oxygen utilized during 7 days is higher with

TABLE III.—Effect of Chloroform on the Deoxygenation Rate of Sewage (Oxygen utilized in mg. per liter)

Chloroform added (c.c. per liter) Days	0	1.0	2.5
1	78.1	36.0	0
2	24.1	49.5	0
3	31.4	31.1	0
4	16.8	22.6	0
5	21.9	33.9	0
6	4.4	33.3	0
7	6.5	16.9	0
Total	183.2	223.3	0

1 c.c. per liter of chloroform than in the sewage alone, indicating that even a substance like chloroform can be oxidized in low concentrations. At 2.5 c.c. per liter concentration, however, oxygen utilization stopped completely, indicating that not only was the chloroform not oxidized but also oxidation of the sewage was inhibited.

Amyl Acetate

Amyl acetate is also used in penicillin production, for extraction of the penicillin. The amyl acetate may be distilled and recovered, but some manufacturers have not as yet installed the necessary equipment for recovery. It is, therefore, of interest to know what the effect of amyl acetate would be on oxidation processes.

The results of an experiment in which various amounts of amyl acetate were added to sewage are given in Figure 2, which represents the cumulative oxygen utilization. The addition of 1.0 c.c. per liter of amyl acetate did not result in any inhibition even during the first day. Thereafter, the oxygen utilization was much higher than in the control. After the 9th day the amount utilized dropped and the curve flattened out. Inhibition on the first day is observed with 2.0 c.c. per liter of amyl acetate.

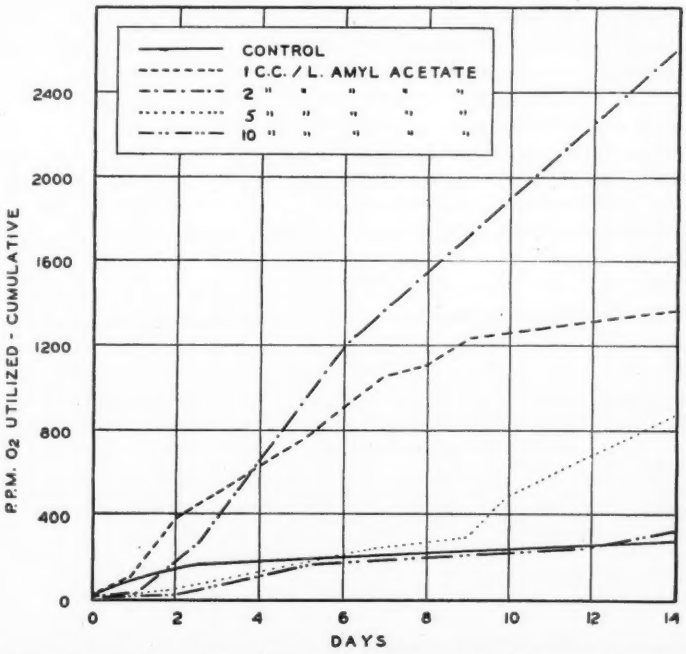

FIGURE 2.—Effect of amyl acetate on oxygen utilization rate of sewage.

Thereafter the amount utilized increased and exceeded the oxygen utilization by the sewage alone, and continued in a straight line up to the 14th day. It is apparent that the oxidation at this concentration was not complete at the end of the experiment. With 5.0 c.c. per liter concentration, oxygen utilization was below that of the control during the first six days, and was slightly above it up to the 9th day. The utilization thereafter increased, but the total amount used was less than that with either 1.0 or 2.0 c.c. per liter. It is apparent that a definite inhibition occurred up to 9 days and that oxidation was not complete at the end of the experiment. With 10.0 c.c. per liter, the oxygen utilization was virtually the same as the control throughout the experiment.

It can be concluded that 1.0 c.c. per liter of amyl acetate has no inhibitory effect on oxygen utilization. The presence of such an amount of amyl acetate should be considered as an additional load which will require a longer period of treatment or larger capacity. There is an initial retardation with 2.0 c.c. per liter; the recovery and oxidation thereafter are rapid but not complete in 14 days. Again this might be considered an additional load. With 5.0 and 10.0 c.c. per liter there is definite inhibition.

Vitamin Production Wastes

As in illustration of the use of the direct method of oxygen utilization with wastes of which the dexoygenation characteristics are unknown, a study of wastes obtained from vitamin B_6 production may be cited. Two different samples of waste from the production of vitamin B_6 were obtained. Sample 1 contained methoxyacetylacetone, sodium acetate, and minor amounts of other soluble organic materials. Sample 2 contained methylmonochloracetate, methanol, chloracetic seed, sulfuric acid. These two wastes were neutralized and seeded with sewage. Concentrations of waste varying from 20 to 1 per cent were prepared by dilution with water and oxygen utilization rates were determined. The B.O.D. was also determined by the regular dilution method. The results are summarized in Table IV.

In Sample 1 the oxygen utilized increased with decreasing concentrations of waste. On the basis of the original waste, the oxygen utilized increased from 160 p.p.m. at 20 per cent concentrations, to 23,730 p.p.m. at 1 per cent concentrations. The B.O.D. determined by the dilution method with concentrations ranging from 0.008 to 0.0025 per cent was 221,000 p.p.m. Somewhere between 1 per cent and 0.0025 per cent the retarding influence of the waste on the deoxygenation rate

TABLE IV.—Oxygen Utilization by Various Concentrations of Vitamin B_6 Wastes

	Sample No. 1				Sample No. 2			
Waste Concentration (%)	20	10	5	1	20	10	5	1
pH initial	7.0	7.0	7.2	7.6	7.2	7.2	7.2	7.1
pH final	6.6	6.8	—	6.9	5.5	5.3	5.3	5.5
Oxygen utilized in 5 days (mg./liter)	32	14.7	148.2	237.3	7.4	11.4	10.5	7.7
Oxygen utilized in 5 days on the basis of the original (mg./liter)	160	147	2,964	23,730	37	114	310	770
5-Day B.O.D. by dilution method (p.p.m.)	—	221,000[1]	—	—	—	104,000[2]	—	—

[1] Dilutions ranging from 0.0008 to 0.0025 per cent.
[2] Dilutions ranging from 0.0016 to 0.0033 per cent.

was removed. The results indicate that concentration of the waste must be reduced below 1 per cent before biological treatment can be efficient.

With Sample 2 the oxygen utilized did not increase with decreasing concentrations of the waste down to 1 per cent. The oxygen utilized in 5 days by the 1 per cent waste was 770 p.p.m. by the direct method, whereas by the dilution method, with concentrations of 0.0016 to 0.0033 per cent of the waste, a 5-day B.O.D. of 104,000 p.p.m. was obtained. It is apparent that the inhibiting influence of this waste is greater than that of Sample 1, and therefore dilution must be even greater to yield reasonable results with biological treatment.

In view of the test and the information obtained, it is obvious that unless such dilution is readily obtainable, either by other manufacturing process wastes or by sewage, biological treatment should not be considered. A further study by this method may reveal a specific agent in these wastes which is responsible for the inhibition, which when excluded or segregated may allow the biological treatment of the remainder of the waste to proceed unhindered.

Discussion

The use and limitations of the dilution method of determining the effect of industrial wastes on dexoygenation have been discussed elsewhere (1). Briefly, the limitations arise from the restricted range of concentrations which can be employed. When the wastes or individual organic compounds are added in concentrations in excess of the solubility of oxygen the results become indeterminate.

As has been shown in the paper referred to above the concentrations of organic matter that can be used are extremely small. No information can be obtained regarding the effect of higher concentrations. The fact that a certain waste or organic compound gives a uniform B.O.D. within the low range of concentrations that can be employed, gives no guarantee that inhibiting materials may not exert their influence at some higher concentration, give lower B.O.D. values and manifest a sliding scale.

For routine work for determining the maximum B.O.D. values the dilution method may give comparable results. It is not the purpose of this paper to discredit the dilution method but rather to show its limitations for special investigations in determining whether a particular waste is amenable to biological treatment and to what extent it may have to be diluted in order to overcome the possible inhibiting action of some specific ingredient in the waste.

For this purpose the use of the direct method seems to be the ideal answer. Due to unlimited supply of oxygen furnished as gas and the agitation to increase the rate of solution of oxygen, no matter how concentrated the waste may be or how high an oxygen demand it may have the demand can be determined without dilution. By successive steps of dilution it can be readily determined whether the oxygen demand decreased in the same ratio as the dilution. In such an eventuality it may be concluded that the oxygen demand is independent of dilution and hence there are no inhibiting agents in the undiluted waste.

It often happens, however, that the oxygen demand decreases less than would be expected from the particular dilution. In other words, the oxygen demand is relatively higher in the diluted sample than in the original waste. It may be concluded in such cases that there was an inhibiting agent in the waste which at some point of concentration was sufficiently diluted, and thereby permitted the oxygen demand to be fully exerted.

The dilution at which this inhibit-

ing action will be counteracted will depend on the concentration and potency of the inhibiting agent. It may take place with only 50 per cent dilution or may require as much as 99 per cent dilution. Increasing dilutions beyond the critical point will then result in proportionate decreases in oxygen demand or constant B.O.D. values. The critical dilution thus determined in the laboratory may then be used as a basis for the design of the large scale treatment plant. It may be that such dilution may be obtained by using water from other sources in the industrial process which do not contain toxic materials, or sufficient dilution may be available by discharging the waste into a municipal sewer. If no source of readily available dilution water can be obtained, or in cases where the dilution required is excessive, ways and means of excluding the particular substance from the general waste should be sought.

In addition, the inhibiting concentration of any specific compound can be tested by the addition of various amounts to sewage and other suitable substrates. The effect of inorganic toxic materials on the deoxygenation rates can be studied in this manner. With organic materials the toxicity may be due to the high concentration of the compound, which upon dilution may be shown to be oxidizable. Formalin and chloroform fall in this category.

There is little doubt that the list of such compounds, which formerly were considered unoxidizable or toxic, can be greatly enlarged. An organic waste which normally would be oxidizable may fail to oxidize because of the presence of certain inhibiting agents. It is also possible to have a type of organic matter which is neither oxidizable nor inhibiting. All of these possibilities can be uncovered by studying the effect of the pure substance or the mixed waste itself. It would be valuable to know the various ingredients in a given waste. From the information obtained by this method, it is possible to ascertain the critical dilution necessary before biological treatment of a given waste. The possible effect on sewage treatment plants can be evaluated if the dilution ratio is known. The effect on the self-purification of streams may also be ascertained.

The observations made in this paper are not concerned with the effect of pH value and nutrient deficiency of a waste, although these factors can also be studied by this method.

In short, the direct oxygen method presents a parallel to the bottle experiments with sludge digestion and gas measurement, which were so valuable in establishing the fundamental phases of sludge digestion and the influence of various environmental factors.

Conclusions

The direct oxygen method permits the study of oxidation rates of industrial wastes at any desired concentration, and the information obtained is valuable in establishing the oxygen demand at any concentration.

If the demand increases with dilution, the presence of a toxic material is indicated, provided the pH and the nutritional factors are corrected.

Reference

1. Heukelekian, H., "The Use of the Dilution Method for Determininig the Effect of Industrial Wastes on Deoxygenation." THIS JOURNAL, **19**, 4, 612 (July, 1947).

Stream Pollution

FEDERAL AND STATE LEGISLATION FOR STREAM POLLUTION CONTROL

By Warren J. Scott

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State Legislation

The writer has tabulated the various agencies engaged in stream pollution abatement work in the different states. While new legislation is constantly being enacted, and it is difficult to keep pace with all the latest developments, the most recent data from the various states are summarized as follows:

Stream Pollution Control Vested in	Number of States
(a) State department of health only...	10
(b) Agency separate from state department of health but closely allied to it, with technical service furnished by state department of health and a representative of the state department of health serving as a member of separate agency.....	11
(c) State department of health and other agencies.....	17
(d) Water pollution control board separate from state department of health handling all water pollution control activities.....	4
(e) No state agency.....	6

In many of the 17 states grouped above under (c), certain specific powers in the field of water pollution control are vested in the state health department and certain powers are vested in another agency. This is true, for example, in Connecticut, where the Department of Health has jurisdiction over the health aspects of sewage pollution and supervises the operation of municipal sewage treatment plants; the State Water Commission is given broad powers to abate pollution and control new sources of pollution, and acts almost exclusively in the field of industrial wastes treatment. Some of the specific powers granted to agencies other than the state health departments in this group are of very limited nature.

There is frequently the cry that the state department of health alone cannot solve the stream pollution problem as there are numerous interests involved such as in boating and fishing and industrial use where other than health aspects exist. This is often the case, and the health department acting singly on health grounds alone may find the going difficult. On the other hand, benefit to the public health is the most important consideration in the eyes of the public and is a dominating factor in selling pollution abatement. Use of streams for water supply, for bathing and for shellfish growth, as well as the absence of nuisance, are all of highest importance from a health standpoint and from the public viewpoint. It must be granted that economic considerations are also of great importance, for municipalities must assume serious financial burdens in many instances in order to provide sewage treatment. Treatment of some industrial wastes is a serious problem because of the cost, and research still has to show the way to practical methods of treatment of certain wastes.

In the long run, there is much to be said for the establishment of state boards on which state health depart-

ments, industry, agencies acting for fisheries or conservation, and possibly other groups or interests, may be represented, with technical service being furnished by the state health departments which must maintain a staff of sanitary engineers to deal with problems of water supply and other sanitary engineering functions. Separate technical organizations are likely to be more expensive and there may be some duplication.

It is encouraging to see the progress that the states are making in setting up legislation. One of the relatively new pieces of state legislation is that enacted in Tennessee, where a commission organized along the lines mentioned above has just been established. New York State is now working officially on a study of pollution control legislation, which will bring forth recommendations that will be considered by the state legislature. A preliminary report by the study group which discusses the problems at issue has recently been published.

Interstate Compact Legislation

There is an increasing interest today in interstate negotiations leading to interstate informal agreements or formal compacts to control the pollution of waters which are common to two or more states. In the Great Lakes Drainage Basin and the Upper Mississippi River Basin sanitation agreements have been reached to work out solutions of problems of pollution control of interstate waters. In the East, there are several examples of the approach through interstate agreements or compacts.

Incodel, an agency interested in water conservation and water pollution problems in the Delaware River Basin, has been established by the states of Delaware, New Jersey, New York and Pennsylvania. It does not operate under a formal compact but rather by the passage of reciprocal legislation in each of the states whereby common objectives are set up and promoted. The agency acts as an educational, advisory and promotional body, and has accomplished a great deal through cooperation of the states and its own activities. Certain standards relating to water quality and acceptable degrees of sewage treatment according to water use have been agreed upon by the subscribing states, and a chronological schedule for the installation of sewage treatment has been set up by the chief engineers of the four state agencies and approved by Incodel and by the state departments of health. The agency issues no orders and enforces no laws. It is an excellent example of successful interstate cooperation without use of the "big stick."

The Interstate Sanitation Commission established by New York, New Jersey and Connecticut has jurisdiction over certain shore areas, mainly adjacent to or near New York City and heavily populated areas in nearby New Jersey, and along the Hudson River and Long Island Sound. Its district embraces only a small portion of all of the waters of the three states. Provision is made for the classification of waters into two classes, according to use. The compact specifies that after classification is made by the commission, certain fixed degrees of treatment of sewage must be provided, the treatment to be accomplished being definitely set forth in the compact. The compact has been favorably subscribed to by all the three states and approved by Congress; it has the force of law and steps are taken to enforce it.

In New England, the state sanitary engineers have been active in promoting a somewhat different type of compact and the state health officers and directors of state water pollution boards have endorsed the project. The idea for this compact rests on the fact that New England is a region of the country with many similar characteristics, natural resources and interests,

and with numerous streams flowing across state borders. It is believed that the general approach to stream pollution abatement in the six states can proceed on parallel lines to quite an extent. It is true that some of the states are more adversely affected by out-of-state pollution than others. It is the consensus of opinion of the state sanitary engineers of New England, however, as expressed at several of the meetings of the Conference of New England State Sanitary Engineers, that the states should band together to solve their pollution problems. An important factor in arriving at this decision is that an approach on a regional basis directed by the cooperating states is believed far preferable to Federal control, even though a receptive attitude is maintained toward Federal advice or stimulation in connection with a national stream pollution abatement program. It is believed that the states are in much more intimate contact with the water use potentialities and the economic aspects of their region than the Federal government.

The legislatures and governors of the states of Rhode Island, Massachusetts and Connecticut have already approved the compact which has been drafted. This action will insure the formation of a compact commission so as to get the work under way. Approval by Congress is being sought. While there appears no likelihood that the three northern New England states will approve the compact this year, it is hoped that they will later decide in favor of joining.

The compact has some interesting features which may be listed briefly:

1. The compact applies to interstate streams, ponds and lakes, and tributaries and tidal waters ebbing and flowing past the boundaries of two states.

2. The New England Interstate Water Pollution Control Commission is set up with five commissioners from each state. Membership must include representatives of the state health department and of any other state water pollution control agency that may exist in the state. Further, it is provided that unless a state so determines otherwise, there shall also be from each state a member representing municipal interests, a member representing industrial interests and a member representing an agency acting for fisheries or conservation.

3. There is provision for appointment of a secretary and clerical staff, but there is no provision for setting up an engineering staff in the commission. Technical experts from each of the states are authorized to confer.

4. The commission is directed to establish reasonable physical, chemical and bacteriological standards of water quality satisfactory for various classifications of use of receiving waters. Each state agrees to submit its classification of its own waters to the commission for approval.

5. Each state pledges to provide for abatement of existing pollution and control of future pollution of interstate waters and to put and maintain the waters in a satisfactory condition consistent with the highest classified use of each body of water.

6. Action by the commission must be approved by a majority of the commissioners of each state, as in the case of the Interstate Sanitation Commission.

7. Specified maximum appropriations by each state for operation of the commission are set up, pro-rated mainly on the basis of populations of the various states.

8. The commission has no power to issue orders.

9. The compact becomes effective when approved by any two contiguous states.

10. Provision is made for New York State to join the compact if the state so desires, but the area of the Inter-

state Sanitation District is excluded. New York State has joint interest with the state of Vermont in certain waters, and to a much less extent with the states of Massachusetts and Connecticut.

It is believed that this compact and the establishment of a compact commission will be a strong motivating force to bring about the clearing up of the interstate streams in New England to the degree warranted by their present and future proposed use.

Federal Legislation

As far back as 1936, the United States Congress has debated the merits of a considerable number of pollution abatement bills. In 1938, a Federal bill was passed by Congress and vetoed by the President. In 1940, principal attention was concentrated on H.R. 4070 which received the backing of many organizations including many state health departments, and H.R. 6024 which was supported by certain groups interested in drastic legislation. Among objections raised to H.R. 6024 were: (1) it provided for classification of navigable waters into sanitary water districts, limits to be fixed by the Surgeon General; (2) it gave the Federal government rather than the states the right to decide on the necessary degree of cleanliness for navigable waters and minimum requirements as to treatment; (3) it provided for immediate drastic action to clean up all sources of pollution whether because of effect on health or on fish or birdlife, which is impracticable and unwarranted; and (4) it set up a water pollution control advisory board of which all of the members were representatives of the Federal government.

It was thought by many, including such organizations as the New England Sewage Works Association and the New England Water Works Association, that it would be preferable in the present session of Congress to endeavor to get behind some reasonable Federal legislation rather than wait to have varied proposed legislation thrust forward. Both associations passed resolutions to this effect at their 1946 meetings. Following the meeting of the Conference of State Sanitary Engineers in Cleveland in the fall of 1946, a meeting was arranged in New York City on November 22, 1946, by Arthur D. Weston, chairman of the Committee on National Water Policy of the Conference of State Sanitary Engineers, and representatives of various groups and organizations were invited to attend. The writer attended the group meeting of 11 persons in New York City as a representative of the New England Sewage Works Association and the New England Water Works Association. Hudson Biery, chairman of the Committee on Stream Sanitation of the Cincinnati Chamber of Commerce, and a previous strong supporter of H.R. 4070, and Kenneth A. Reid, Executive Director of the Izaak Walton League of America, who had previously supported H.R. 6024, were present. As a result of this meeting, general agreement seemed to be reached on a bill very similar to H.R. 4070 but including a new provision to the effect that the Surgeon General may take legal action if all efforts to secure state or interstate action fail. The bill agreed upon was subsequently introduced in the present (Eightieth) Congress as S. 418 (Senators Barkley and Taft); H.R. 315 (Congressman Spence); and H.R. 470 (Congressman Elston).

S. 418 (and the companion bills) designates the Surgeon General in charge of water pollution control; provides for cooperative state and Federal action and approves interstate compacts; provides for grants-in-aid or loans to states, municipalities and other public bodies; provides for loans to industry; sets up an advisory board with broad representation of inter-

ests; sets a maximum appropriation for grants or loans of $100,000,000, such grants-in-aid not to exceed 33⅓ per cent of the cost; and authorizes an annual expenditure of $1,500,000 by states or interstate agencies which may be used in part to defray cost of studies, research and engineering reports. Section 2(d) states that when the Surgeon General finds that pollution of interstate waters jeopardizes the health or welfare of citizens of the United States, he shall bring the matter to the attention of the appropriate state health authority or interstate agency and may recommend or specify that remedial action be taken. *Such recommended remedial measures must be reasonable and equitable.* If such action is not taken within a specified time, the Surgeon General may recommend to the state or interstate agency that legal action be taken. *If legal action is not taken within a reasonable time, not to exceed two years, the Surgeon General may initiate legal action in the United States courts.* (The italicized words in this paragraph constitute additions to the provisions of H.R. 4070.)

Subsequently H.R. 123 was introduced by Congressman Mundt. This bill is similar to S. 418 and its companion bills except in two respects. The first difference is that a provision is added that after enactment of the act, no new sources of pollution shall be permitted without approval of the state health authority and the Surgeon General. While the purpose of this provision is laudable, the definition of what is a "new source of pollution" is uncertain and it appears that this provision may be opposed by industry on the ground that unreasonable interpretation might be made. Would new connections to an existing sewer or a change in an industrial process constitute a "new source of pollution"? At recent Congressional hearings on S. 418, when amendments were offered to make it similar to H.R. 123, it is understood that the proponents of the changes suggested that the prohibition apply to "new sewer outlets," which is somewhat more definite but still open to some question.

Another difference between S. 418 (and companion bills) and H.R. 123 is that an additional section in H.R. 123 provides that if the water pollution advisory board finds it is impossible or impracticable for a municipality or industry to provide adequate treatment because of financial inability, the Surgeon General shall not bring a court action within such period of time as may be determined by the board to be necessary, such period not, however, to exceed five years; extensions of time may be granted if the board is satisfied that reasonable progress is being made. There is some argument in favor of this second difference and the additional provision in H.R. 123 may be desirable.

At least, these two bills represent a nearer approach to agreement among interested groups than has ever been the case previously.

Some individuals and organizations have definitely opposed the principle of Federal financial aid for pollution abatement except as part of a general public works program. Arguments have been heard that municipalities and the states are in as good or better position than the Federal government to finance needed work. On the other hand, Federal aid is being dispensed in many other fields, debatable as may be the advisability of some of these expenditures, too. The writer does not believe that Federal financial aid in the form of grants-in-aid or loans is a "must." Some opposition is also voiced to the provision in the new pollution control bills that, failing state or interstate action after a reasonable time, the Surgeon General may institute legal action. However, if the Federal government is to be made a party

to a national program of pollution control through Federal legislation, it appears to the writer difficult to justify its exclusion from any manner of enforcement whatsoever. Present Congressional bills lay a great deal of stress on machinery for state and interstate action rather than Federal legal action.

Two other bills introduced in the Eightieth Session of Congress are of interest. These bills are identical bills, S. 244 and H.R. 1047. The bills are introduced in the interest of encouraging the prevention of stream pollution by industrial wastes through allowing sums paid for treatment of industrial wastes, including amounts paid for plans for construction and treatment, to be deducted by industry in computing net income for taxation purposes.

Summary

The pollution problem has unquestionably grown beyond state borders. Discharge of sewage and industrial wastes in one state may and frequently does affect the water use in a neighboring state. This fact alone, however, does not make Federal pollution control necessary. Without additional legislation, legal action in the Federal courts may now be undertaken where real damage occurs, even though this is not the most desirable solution of interstate pollution problems. As shown by progress already made, states can join together through interstate compact agreements on a unified water pollution control program. Surely this approach by interested neighboring states which are so intimately concerned with regional water use problems, especially the potential water uses that should be planned for on each watershed, is preferable to granting broad mandatory powers to the Federal government.

Perhaps the principal service the Federal government could render would be to promote, coordinate, and even carry out research in the field of sewage and industrial waste treatment, particularly the latter. The development of practical treatment methods for many industrial wastes is a hurdle yet to be overcome. Some state agencies have done splendid research work but the results are not well coordinated and one state is frequently unaware of research in another state or of studies by private industrial groups.

The slowness of action on the part of some states to accept their responsibilities in the field of water pollution control will hasten the day of Federal legislation. Such legislation, if enacted, should be restricted to interstate streams, should foster the formation of interstate compacts and should limit the issuance of Federal orders for abatement of pollution of interstate streams to extreme cases where states will not assume their responsibilities. With awakening action by all those states which to date have failed to undertake any pollution control programs, and with increasing adoption of the interstate compact approach, the Federal government would then need to act only as a coordinating agent and as a sponsor of research to work out practical ways and means of treating all types of wastes before discharge into streams, to the degree called for by the present and probable future use of streams, with due regard to the benefits and the costs.

Existing concentrations of municipal sewage pollution and industrial wastes pollution have grown to their present proportions over a span of many years. Industries and heavily populated communities are a part of modern civilization. We cannot hope to restore *all* streams to their state of pristine purity as some enthusiasts have advocated,

certainly in the light of all known scientific advances, unless, as one worker in the field recently put it, we wish to "turn the country back to the Indians." Yet, reckless and unwarranted pollution of water resources must be controlled, and waters must be improved to the extent justified by their present and planned future uses, whether for water supply, for bathing, for commercial or recreational fishing, for boating, for industrial purposes, for irrigation, or for navigation.

THE OPERATOR'S CORNER

CONDUCTED BY S. C. MARTIN

INTRODUCING MR. MARTIN

Operators, it is a pleasure to make you acquainted with Sylvan C. (Sandy) Martin, who henceforth will assemble the material presented in *The Operator's Corner*. This introduction is quite unnecessary to Illinois operators, to whom Martin is both well-known and held in high regard; it is more of a general notice that you will all be hearing from him in the future and that his first responsibility is to make the *Corner* as practical and useful as possible.

Although a number of our readers have been kind enough to comment favorably on the present content and style of this department of the JOURNAL, the writer has felt that there is great room for improvement. He has been particularly conscious of this feeling during the past two or three years, when administrative and management functions have imposed on the time required to do full justice to the *Corner*.

During his seven years of service in the sanitary engineering staff of the Illinois Department of Public Health, Martin has enjoyed close field contact with sewage works operation, and has a thorough understanding of the problems of the operator. He has been active in the conduct of operators' meetings and short courses, and in the administration of the Illinois voluntary certification plan for operators. A fine background of training and research in sanitary engineering further qualifies him for this assignment.

But assistance is needed—your assistance. The best material for use in the *Corner* is that which originates with plant operators, whose obligation it is to see that Martin is kept supplied with plenty of good copy. Short or long articles, annual operation reports, local newspaper clippings, or just letters describing some problem, gadget or operation kink are welcomed as source material. These contributions need not be masterpieces of literary composition, for we will be glad to undertake such refinement as may be required.

Every operator has at one time or another circumvented minor or major difficulties by some original device or procedure. These things are usually taken for granted, on the modest assumption that the solution was so simple that anyone would have thought of it. Also, many unusual incidents occur to plant operators, most of which remain untold unless they are brought to light in those story-telling sessions that are such a feature of sewage works meetings. You will benefit from the experience of other operators. Reciprocate by making your experience available in return, through the medium of the *Corner*.

With your help, which we are sure will be forthcoming, the *Corner* has good times ahead. As "Associate Editors," all operators are urged to assume a proprietary interest in the department. We are providing Mr. Martin with an oversize desk tray so that there will be room for all your letters—contributions from your day-to-day experience and constructive suggestions as to how the *Corner* may serve its purpose to maximum advantage.

W. H. W.

SEWER MAINTENANCE PROBLEMS *

By Harry Fitts

Engineer, Sewer Maintenance Bureau, Borough of Queens, N. Y.

Queens County, New York, is one of the five borough subdivisions of New York City and it has a population of about 1,456,000 spread over an area of 75,000 acres. This is almost twice the population and nearly three times the area of the city of Boston.

Description of System

At the present time in the Borough of Queens there are about 1,250 miles of sewer of which two-thirds are combined sewers and one-third are separate or sanitary sewers.

A proponent of either the combined system or separate system of sewers, given a set of favorable conditions, can make an excellent case for either type but from the viewpoint of maintenance a separate sewer system has proved to be a source of endless trouble in Queens. During the building boom in the Twenties and Thirties large subdivisions were developed with homes constructed on relatively small lots for which separate sewers were provided by the developers. As many of these developments were miles from tide water, construction of storm sewers or combined sewers in the very large sizes required by the topography would have been confiscatory. Consequently, although plans for separate sanitary sewer systems and storm sewer systems were developed, only the sanitary sewers were built and, until recently, very few storm sewers have been provided.

Separate Sewer System

Under the pressure of public opinion many of the sanitary sewers which were installed have become under-designed combined sewers by the admission of storm water from private house leaders and from the construction and connection of catch basins by public and private agencies. During and following a severe storm it is not now uncommon for the Sewer Maintenance Bureau to pump out 500 to 600 cellars which have been flooded by the backing up of sewage from the overtaxed sanitary sewers. To provide this service the Bureau maintains more than 40 portable pumps ranging in size from 2 to 6 inches.

Many home owners have been forced to install check valves and manual shut-off valves on cellar drain lines in order to prevent the flooding of their basements during and following storm periods. To them this seems an unwarranted expense, as it does to the Bureau, and they feel they should have trouble-free use of the sanitary sewer. Because, however, of the time lag of several years between the construction of the sanitary sewers and the storm sewers, trouble-free service from the sanitary sewers is seldom obtained.

Partial Capacity Combined Sewers

Another aspect of the same problem has been the construction of large combined sewers of less than the ultimate design capacity. For example, if the drainage plan indicated that a given area should be drained by a two barrel sewer to accommodate 1,000 c.f.s. and the near future state of development warranted only one-half this capacity, only one barrel of the sewer was built. At the time it seemed economically unreasonable to put an extra million dollars worth of concrete and steel into the ground to lie virtu-

* Presented at the Joint Meeting of the New York State Sewage Works Association and the New England Sewage Works Association; Albany, N. Y.; May 26–27, 1947.

ally idle for 20 years. Also considered was the shallow depths of flow which would occur during the early years and the resultant lower velocities and increased deposition of suspended matter.

This practice of building partial capacity combined sewers has now been abandoned. When a community now petitions for the construction of a trunk or sub-trunk sewer it receives the sewer called for by the overall sewer development plan. Consequently, in the future sewer maintenance engineers will not have to spend time trying to explain to delegations of irate taxpayers why basements of two or three blocks of houses repeatedly flood when connected to a city sewer for which assessments have been paid.

To those not in the engineering profession there is no distinction between kinds of sewers. If a man has a sewer in front of his house for which he has paid money, he feels it should accomplish all things and if it is a combined sewer adequately designed and properly constructed it just about does that, within the limits of the rainfall frequency curve used as the basis for its design. If the sewer to which a taxpayer's house is connected is a sanitary sewer, the taxpayer finds it incomprehensible that the municipality neglected to build storm sewers in the first place. He does not remember that he bought the property because of its attractive selling price. Even in rare cases where a trunk storm sewer is already in the ground, the general practice of requiring initiation of lateral sewer construction by the residents of the area concerned brings out the obvious fact that before lateral sewer construction can be effected there must first be occupied houses in the area, some of which will be inconvenienced by storm water before adequate sewers are provided.

It is realized, of course, that cities that have grown at a uniform rate are less apt to develop the objectionable situations discussed above. In Queens the population sky-rocketed in the space of a few short years leaving the maintenance of the sewers in a large part of the country a matter of perpetual compromise between expediency and good practice.

Design Considerations Which Affect Sewer Maintenance

There are many things which the designers of sewers can do to facilitate maintenance and cleaning problems. For example, a 20-in. cast iron force main crosses Flushing Meadows on piles and at two points there are bends of more than 45 degrees deflection. Several years after construction both of these bends separated from the pipe probably because of water hammer created when the checks closed. These separations resulted in difficult repairs. The answer to this problem was found in the use of lug or beaded pipe and fittings with tension rods which, of course, is standard water main practice on bends. This type construction could have been incorporated in the original project with the resultant prevention of a difficult and expensive maintenance problem.

Regulators—Weirs

The maintenance crews of the Bureau have never been able or willing to give regulators the attention they require. For this reason all separation of flow is now accomplished with fool-proof weirs of one form or another. One of these weirs is 126 ft. long and overflows into a partial capacity sewer section 31 ft. wide and 22 ft. high, inside dimensions. These ridiculously large sizes for the area drained were required by very unfavorable topography.

Inverted Siphons

Inverted siphons in the smaller pipe sizes are built in Queens with a split cast iron pipe inserted in both ends

of the bottom pipe near the elbows, with manholes located directly over them. Ready access is thus possible by simply unbolting the top half of the split pipe. For large size siphons it is imperative that the several siphon barrels terminate in a common chamber. The chamber should be so arranged that suitable planks can be set in wall grooves so that any one of the siphon barrels can be isolated for cleaning with complete safety. Recently a three-pipe siphon had to be cleaned at great cost due to the absence of such simple means of bulkheads. Tight bulkheads permit dewatering and working in the dry with hand labor and wheelbarrows.

Shafts

For economic reasons there seems to be a disinclination on the part of design engineers to provide sufficient shafts on tunnel sewers. One 11-ft. 9-in. circular combined sewer at Queens has shafts up to 70 ft. deep located as far apart as 2,900 feet.

The sewer velocity at 0.8 depth is 9 f.p.s. or 6 m.p.h. and at dry weather flow the velocity is about 4 f.p.s. In view of the slimy invert on which men cannot hold their footing, an examination of the condition of this sewer after 20 years is difficult.

Since the shield got out of line during the driving of the sewer, powerful searchlights will not show through between shafts, for this was tried. If part of the lining was to need repair and access could be obtained, the dry weather flow could probably be flumed but sudden storms build up fast and if one broke how could the repair crew be removed? Here again foresight on the designing engineers' part can eliminate an almost insoluble problem for the maintenance engineer.

The galvanized wrought iron stairways in all of the combined sewer shafts have badly corroded and require replacement after 20 to 30 years of exposure to mixtures of gases and moisture. If it is conceded that the life of monolithic concrete sewers, as recently built, is at least 100 years, the need for a more durable stairway material is apparent. The cost of the more durable material and its fabrication could be three or four times the cost of present galvanized wrought iron and the more durable material would still be economical. Wire brushing and coating with bituminous or resin based protective coatings are not only expensive but, where there has been a definite loss of section, are also impractical.

Cleaning Basins and Sewers

Basin Cleaning Machines

At the present time the Bureau has 13 basin cleaning machines and 6 sewer cleaning machines, all motor-truck mounted. The basin machines require two dump trucks since a considerable haul is required to the few dumps remaining available. One dump truck is filled while the other is on the road.

Other cities have had excellent success with the dump body mounted on the same chassis with the crane. The Borough of Manhattan has 12 of these. In traffic congested communities where hauls are short, the self-contained rig has a great deal to recommend it.

Basin cleaning machines have been used by the Bureau for excavating in sandy soil and have been found to be very adaptable. On one occasion an 18-ft. special boom with a heavy casting hooked to the hauling line was used to knock down a concrete wall by swinging the casting against the wall. The equipment manufacturer would probably hesitate to recommend such a practice but expediency was the mother of this adaptation.

Material Disposal

The disposal of material removed from basins and sewers is becoming a

serious problem. Eventually this material will have to be dumped at sea. At the present time the Department of Public Works sludge vessels are only equipped to handle pumped sludge so the sewer maintenance bureau payroll may soon carry the anomalous title of barge captain.

Sewer Cleaning Machines

The sewer cleaning machines used have a triple drum hoisting assembly with steel mast and 13-ft. boom. The drums accommodate 450 ft. of 7/16-in. draw cable, 900 ft. of pull-back cable and 200 ft. of boom release cable. Operations can be performed 300 ft. each way from a single manhole, resulting in the cleaning of 600 ft. of sewer with one reversal of the machine's position and a switch of dead-men. The load is taken off the rear wheels by the usual screw jacks.

The limitation on the size of this machine and its buckets, and thus the removal rate, lies in the least diameter of manhole frame, with due consideration being given to the reduction in the effective passing area by the manhole steps near the top. The Bureau has used buckets of the following sizes: 18 in. by 36 in., 15 in. by 30 in., and 12 in. by 24 in. Of these the 18-in. bucket is the one most used.

Contract Cleaning

With the present facilities of the Bureau no attempt is made to clean the larger sewers if the deposits are extensive. All of this work is done on a contract basis. At the present time a contractor is cleaning a 900-ft. stretch of 84 in., 90 in., and 96 in. sanitary sewer in which 960 cu. yd. have accumulated, or nearly a yard per foot of sewer. This sewer traverses the new Idlewild Airport for practically the entire contract. Because of many anticipated difficulties, all of which are enumerated in the specifications, the low bid for cleaning was $9.40 per cu. yd. Some of the difficulties never materialized because of progress on the airport construction. For example, a haul of the moved material was not required; the contractor had only to spread the gravelly material on the airport in advance of the graders.

The equipment used is fairly standard for work on a sewer where the flow cannot be by-passed. Manholes were first broken down at points 400 to 600 ft. apart until the 4-ft. square section was reached. This was necessary in order to pass a one yard bucket. A ⅝-in. diameter cable was fastened to the bail end of the bucket, passed up stream to the manhole, through a snatch block and up to the hauling drum on a crawler crane. Another ⅝-in. cable was attached to the bottom of the bucket and passed to the downstream manhole, over a sheave and up to a gasoline winch. After the winch makes the back-pass with the crane cable slack, the crane picks up the haul. When the bucket reaches the snatch block one man has to be in the sewer to slip it off when the operator gives him slack. Then the crane has a straight pull-up and is able to swing the bucket over the truck. It is dumped by using the crane's closing-line shackled to the bottom eye at each dumping.

Bucket Alterations

The material found in the sewer was consolidated gravel and sand mixed with asphalt and road oil. In this material the bucket just dug a channel. Use of the bucket seemed impossible until the contractor conceived the idea of cutting a slit on three sides 6 in. below the rim and then bending out a lip with a 4-in. opening to scoop in the material. This did the trick. After being placed in the dump truck the removed material does not have much water in it as the

water either leaks out around the tailboard of the truck or spills off as supernatant when the body is full. No allowance is made for heaping.

Manhole Location

Trunk sewers of large size must be cleaned mechanically. This means that the cleaning equipment must be properly placed over the center line of the sewer. The sewers recently constructed all have cleaning shafts located along a line transverse to the line of the sewer and at convenient intervals. For example, a three barrel 16 ft. by 10 ft. sewer now under construction has groups of cleaning shafts—one on each barrel—located about 500 ft. apart and on the centers of each roof. Ladder manholes are over the separation walls and are spaced 160 ft. apart. At these points a space is left in the wall and a ladder run down the wall edge. The opening serves also as an equalizer. A man can walk freely across to all three barrels and is handy to the clean-outs when dead-men have to be set for cable equipment anchorages. Although timber dead-men are now being used, consideration is being given to the idea of placing eye-bolts in the concrete walls to which chains can be hooked.

Costs

The last real attempt to arrive at costs for basin and sewer cleaning accomplished by Bureau personnel was in 1942. The cost of removing basin material was $2.32 per cu. yd., including gasoline, oil, repairs, depreciation of equipment, direct labor cost and overhead. This compares with approximately $7.00 per cu. yd. for hand removal. The sewer dragging machines have such varied weekly removal capacities that only an intelligent guess can be made as to the cost. Probably $3.75 per cu. yd. is not far from correct.

OPERATION AND MAINTENANCE OF A SMALL ACTIVATED SLUDGE PLANT *

By Leonard S. Hillis

Superintendent, Sewage Treatment Plant, Caro State Hospital for Epileptics, Caro, Mich.

The Caro State Hospital is located about four miles southwest of Caro, Mich. on the Cass River, a branch of the Saginaw River. The sewage treatment plant serves the institution only, a population of about 1,700. The average flow per capita is 105 g.p.d., making a total average flow of 180,000 g.p.d. Most of the sewage reaches the plant by gravity, while the remainder comes from patients' quarters located on the south side of the river, and is pumped under the river to the plant.

The plant consists of a comminutor, one 21,000-gal. primary settling tank, three 40,000-gal. aeration tanks with mechanical aerators, two 18,000-gal. final settling tanks, a chlorine contact chamber, a 100,000-gal. floating cover digester, and glass-covered drying beds. The primary and final settling tanks are of rectangular design with chain flight collectors.

The writer's four years of experience in sewage plant operation have been confined to this small activated sludge plant. When going into the plant for the first time he was absolutely ignorant of the principles of ac-

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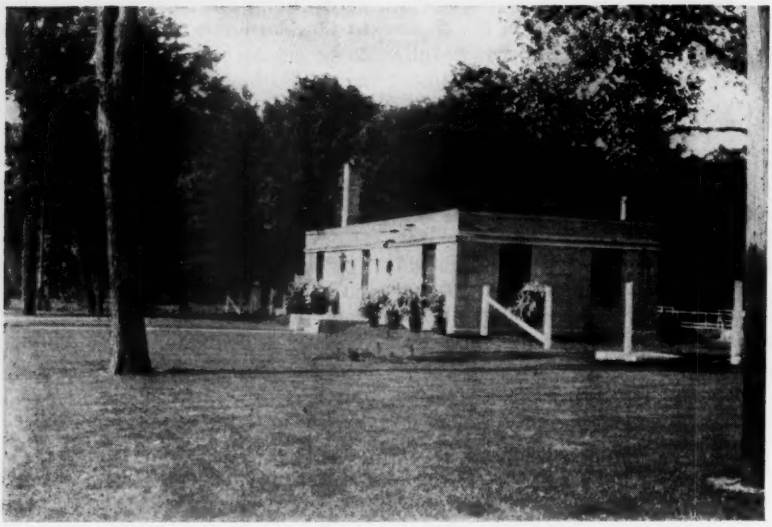


FIGURE 1.—View of Control Building at the Caro State Hospital sewage treatment plant.

tivated sludge sewage treatment. After he had been at the plant a few months, had studied available books, materials, and past records, had carefully examined construction blueprints and manuals, had attended one short course and conference at Michigan State College, and had seemingly brought the plant to a point of successful operation, he felt that he knew practically everything there was to be known regarding sewage treatment. But, as time went on, this viewpoint underwent a marked change, when one new problem after another presented itself.

The answers to most of these problems could not be found in books, and the procedures that appeared promising, when tried, often did not work. One cannot successfully operate a plant simply by following the instructions of others. He must know the sewage characteristics and the plant, and then by coordinating what he has learned from others with what he learns through experience, along with a little good judgment and perseverance, he can become a successful sewage treatment plant operator.

The operator should know the stream or body of water into which the plant effluent flows, and to what use this stream or body of water may be put. It may be that the effluent does not need to be of high quality, but a good operator will not be satisfied with a poor effluent if it is possible for his plant to produce a better one with little or no additional cost of operation.

While he is given the title "Sewage Treatment Plant Superintendent," this being a one-man plant, the writer is also the chief operator, the laboratory technician, the laborer, and so on. There being only one operator means, of course, that he is usually on duty only during regular working hours, except when duty insists that he cancel some pre-arranged plans to take care of unpredictable emergencies.

The small plant operator is in a position to know his plant better than the large plant operator, as he alone

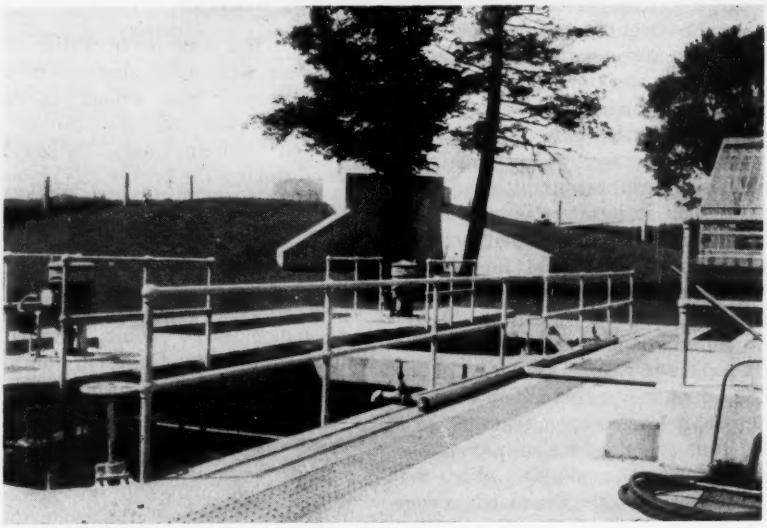


FIGURE 2.—Caro State Hospital sewage treatment plant. Aeration units in foreground and digester at rear.

is in personal contact with each and every part of it. He performs the minor duties along with the important duties, and if anything is not done correctly, all he must do is correct his own errors and not the mistakes of others.

The responsibilities and duties in a small activated sludge plant are in every way as important and numerous as those of a large activated sludge plant, at least as far as actual plant performance is concerned.

Operating Observations

This being a mental institution, most of the sewage flow comes during the day, with a high percentage of laundry waste. About 65 per cent of the average week day flow comes between 8 A.M. and 6 P.M. and about 40 per cent of that flow is laundry waste. Almost every plant has some particular waste that is outstanding and is often difficult to treat, as in this case the laundry waste. In this plant the soapy waste tends to cause a light and fluffy activated sludge, which sometimes behaves like a bulking sludge during peak flows, but if kept under control will turn out a sparkling clear effluent.

Some of the operating problems brought on by the exceedingly wide variation between day and night flow rates are (a) too short a retention period in primary tank during peak flows and (b) much too long a retention period during night flows, especially during the hot summer season, often leading to creation of a septic condition and formation of hydrogen sulfide. To overcome this condition the first aeration tank is used for preaeration of primary effluent only, so when it enters the second aeration tank, where it is mixed with the activated sludge, it contains a dissolved oxygen residual and is in better condition to receive the activated sludge.

With such extremes in sewage flow it is difficult to obtain maximum aerator performance at all times. If aerators are adjusted for the average rate they will flood during high day flows

and surge during the low night flows. Attempt has been made to correct this, but with only partial success, by adjusting the aerators for maximum performance during peak flows and inserting a partial gate in the channel to the final tanks to hold a higher level in the aerators during the night.

Even then it is often impossible to keep an adequate dissolved oxygen residual in aeration and final tanks during peak flows to keep the return sludge in a healthy condition. It has been found that between 1,600 and 1,800 p.p.m. of suspended solids in the mixed liquor will withstand shock loads better than lower concentrations, provided that an adequate supply of dissolved oxygen is available. With mechanical aerators the dissolved oxygen supply is so limited that during hot weather it is necessary to lower the mixed liquor solids concentration in order to insure enough dissolved oxygen. Even with low aeration tank solids the dissolved oxygen residual often falls to less than 1 p.p.m. in the aeration tanks and to zero in the final tanks.

Reference to shock loads does not necessarily mean unusual wastes. The laundry is at rest Saturday afternoon and Sunday, so on Monday the laundry waste is a shock load both in B.O.D. and quantity. On Tuesday the flow is about the same, but the shock is less apparent, and by the end of the week the plant is acclimated to the load. For best operation it is thought best to carry as high a concentration of activated sludge as needed to handle shock loads, provided an adequate amount of dissolved oxygen is available for that concentration.

The writer's efforts in using chlorine to correct bulking of activated sludge have met with some success, but the practice has its disadvantages because in the process it seems to separate the grease, leaving it to float on the surface of the final tanks. This gives the tanks a bad appearance.

Seasonal Problems

One of the seasonal operating problems was definitely eliminated when a huge poplar tree, which practically overhung part of the tanks, was trimmed to the ground. The shade is missed during the lawn-mowing season, but there are now no leaves to plug the mechanical aerators and the return sludge pump. One aerator motor was burned out because of the impeller being stalled by leaves. On several occasions the "non-clog" return sludge pump was found in the morning to be completely plugged with leaves, resulting in a layer of sour sludge on the surface of the final tanks.

Another of the seasonal or almost seasonal operating problems comes during the spring thaws when the ice of the river, en route to the Saginaw Bay, jams and causes the river to rise high enough to flood the tanks completely, thereby interrupting plant operation for from three to five days. This has happened three of the five spring seasons that the writer has been at the plant. The interruption usually means starting from the beginning to build a new activated sludge, as well as a lot of extra cleaning.

The nuisance and operating difficulties created by the *chironomus* larva and fly during the first and second summers at the plant were completely eliminated by screening over the chlorination chamber where most of the flies seemed to hatch. The use of fly sprays and DDT has also helped.

Digester Operation

To date the digester has given little trouble. It is usually possible to find supernatant with less than 500 p.p.m. suspended solids. The pH ranges from 7.0 to 7.3. There is enough gas produced to keep the digester temperature between 85 and 90 degrees, except during the winter months when digester heating is supplemented by the plant heating system.

Both the raw sludge entering the digester and the digested sludge are of low solids content—about 3 per cent dry solids—but the digested sludge usually dries readily. Disposal of the dried sludge is no problem as it is hauled away by an institution truck and used on the hospital vegetable and flower gardens.

The digester scum layer which has been forming since the digester was put into operation in 1940 is beginning to create a problem. The layer is probably 5 or 6 ft. in thickness and is occupying space that is needed for active digestion. The only way to remove the scum layer successfully is to empty the digester completely. This is not easy to do when only one digester is available.

When supernatant seems to be deleterious to the activated sludge, it can be lagooned without creating a nuisance.

Maintenance Philosophy

In a small plant the operator is also the maintenance man, so it is natural that he follow the slogan, "A stitch in time saves nine." Proper lubrication, painting at right time and choosing the right paint for the right job, and caulking cracks in concrete to prevent further corrosion, are a few of the measures that may prevent costly repairs. There are many maintenance and repair jobs that a single operator cannot do alone, but he can do a lot toward minimizing expense by having everything ready so that when help does arrive no time will be lost.

This is a relatively new plant so the maintenance problems have not been too outstanding and it is hoped that, as equipment parts begin to show definite signs of replacement need, they can be replaced without waiting an indefinte period. The comminutor is still doing its duty, although repair parts were ordered for it last fall, expecting they would be needed before the winter had passed. They still have not arrived.

There are two types of cleanliness which the successful operator will have recognized: the cleanliness that is essential only to efficient plant operation, and the cleanliness that meets the public eye. The efficiency of the operator will not be measured by just one or the other, but by both. Visitors, as well as your superiors, will partly measure your ability by the odors, or lack of odors, surrounding the plant. Quite often unpleasant odors can be eliminated or kept at a minimum by thorough cleanliness.

Cleanliness and tidiness also apply to the operator. Clean work uniforms tend toward a better reputation. Neat appearing grounds surrounding the plant are an additional asset to the operator, but the grounds should not be so lavish in a one-operator plant as to require time that is needed for actual plant operation.

BARK FROM THE DAILY LOG

By Walter A. Sperry

Superintendent, Aurora (Illinois) Sanitary District

May 5—Not all the duties of a plant operator deal with sewage or with the cold, impartial realm of figures. On January 1, 1947, the District started participating in the rights and benefits of the Illinois Municipal Retirement Fund. These benefits include a retirement pension, disability protection and a death settlement for all employees.

Last January 10th our lovable old Irish watchman died. He had been

with us for 15 years but for the last 3 years had been home ill and had been receiving a small pension, which was sorely needed. Although before his death he had paid only $1.50 into the Retirement Fund, his widow received a death benefit check for $960. Our district president and your Logger will not soon forget the pleasure derived from presenting that check to Mrs. De Vine.

May 28—The May, 1947 Log told our story of the cleaning and repairing of primary digester No. 1. Subsequently a shaft packing problem developed that nearly had us licked. A severe gas leak developed under the 5-ft. bullwheel that drives the 4-in. shaft which carries the scum breaker arms and the bottom plows. This shaft passes through a sleeve in the roof of the digester. Between the shaft and the sleeve is a ¾-in. annular space. The sleeve is about 18 in. long and was planned to project sufficiently below the underside of the roof to seal off the escape of gas. While this plan has functioned well on digesters Nos. 2 and 3, it failed on digester No. 1. Efforts to push several rings of packing into the annular space failed to stop the gas leak, partly because the packing pushed through at the lower edge of the sleeve. A split collar applied to the shaft at this point failed because (1) the gas pushed the packing out of the top of the sleeve, and (2) the shaft, being slightly bent, caused an alternate tightening and loosening of the packing as the shaft revolved. The use of "L" hooks and a clamp band failed to keep the packing from pushing out at the top.

After studying the characteristics of several types of soft braided packing, we tried common oakum, not too tightly placed and held in at the top by a second split collar. This plan worked as we thought it might. The oakum swelled with moisture, was still soft enough to take up the eccentricity of the bent shaft and was further sealed from below by a gradual accumulation of fine particles of sludge which were blown into the sleeve packing at the bottom by the gas. We've had no trouble since!

June 17—Today's telephone adventure was a frantic call from the field inspector for the State Division of Waterways who had discovered that a 3-ft. by 5-ft. iron cover grating had been tipped into a 16-ft. well at the fish trap on the Main Street dam. The resulting uncovered opening created a dangerous safety hazard in the heart of the city that the inspector apparently could not eliminate.

For years we as a District have been cultivating the good will of the city departments by furnishing them free distilled water for their car batteries. Having a surplus of gas, distillation of this water cost us nothing. We drew on this reservoir of friendship and in twenty minutes a Fire Department crew had fished out the grating with long pike poles. Later we spot-welded one end of the grating in three places. This made the grating easy to raise when necessary and is better than locks or bolts for preventing vandalism by youngsters.

June 24—Here is an item for Ripley! If sewage works operators were as resourceful as Old Mother Nature, few of their problems would go unsolved. The accompanying picture shows a young hackberry tree's effort to grow through a 6-ft. woven wire fence that surrounds the secondary settling tank. Due to screening bushes no one had noticed what had happened. The young tree pictured (Figure 1) is 4 to 5 inches in diameter. Along the center line of its trunk, the tree has grown completely around the fence wire.

June 30—The obligation to issue an annual report is very real. As a record of stewardship and accomplishment, it is a must job. The finding of enough time to compile and write the report, however, "rides" one like

Sinbad's "Old Man of the Sea"! Today we completed the final dictation of our annual report. The rest of the work is mechanical and easy. Oh, what a beautiful morning! Oh, what a wonderful day!

July 9—Donald Henn, superintendent, DeKalb (Illinois) Sanitary District, ran headlong into an industrial waste problem at his plant, according to a letter received from him today. He related that one Monday morning he found that his plant treatment processes had completely broken down. Gas production was down, all growth had completely sloughed off the top trickling filter stone, the final effluent was high in suspended solids and B.O.D. Fish were reported dying in the river and innumerable quantities of worms had sloughed off the filters into the final tank.

Armed with a pH outfit Don and his assistant began to check the sewer system. Eventually they found a suspicious flow and traced it to a garage in which a plating company recently had been started. Workmen had been adjusting a zinc cyanide plating solution and several times, while making successive dilutions, had dumped a few gallons of the solution to the sewer, quite unaware of the trouble it could cause. Don is a diplomatic chap and the company was quite apologetic, promising full cooperation in the future. Less than 1,200 gal. of the plating waste had caused a complete breakdown of the biological sewage treatment processes. Within a few days conditions at the plant righted themselves and in all likelihood cyanide wastes will not soon be a problem again in DeKalb.

FIGURE 1.—An item for Ripley—a tree with an ingrown fence!

July 13—We made what turned out to be a wise decision today. For sixteen years the pump room walls at the Aurora plant have retained the cement wash coating originally applied. With the walls darkened and streaked by time and spotted by roof leakage the room had lost its attractiveness despite the colorful effect of the floor, the engines, and the pipe coloring scheme. Since we are to be September hosts to the Illinois Association of Sanitary Districts, and naturally want to look our best, we decided to paint the pump room. The job was difficult due to a 35-ft. ceiling, large areas and some places difficult to reach. At first it looked like a spray job. However, very high rental costs for spray equipment, the necessity for using large canvasses and dragging around long hose lines, the time lost in cleaning and tinkering with sprays, and the final cleaning-up needed afterwards tipped the scales in favor of the paint bucket, brush and ladder method.

The painting was done as we found time to do it and proved to be much less expensive than anticipated. Only one 40-ft. ladder was purchased and no canvas was used. The pump room

is now attractive in its new color of palm green.

July 16—There is a first time for everything. We gladly accepted an invitation today to talk at a public meeting at a small rural school near Aurora. Our subject: "The How and Why of Septic Tanks." This was our first time to appear in this role.

We talked and sketched for an hour, emphasizing the wisdom of following the simple workable plans provided by the State Department of Health, and advising strongly against the purchase of proprietary tanks that so soon give trouble. We feel sure that we helped our listeners and have marked down the adventure as a worthy service to the community.

July 23—Completed revamping an old visitors' exhibit today. For years we have had a display panel on which was sketched the Fox River from the Wisconsin line to its mouth at the Illinois River. All of the cities and towns located along the Fox were spotted on the sketch and a picture of the local sewage plants, together with a brief note, was shown for each. This panel has been a valuable exhibit for speaking dates, especially since there is a widespread local belief that the Fox River is one of the cleanest streams in the United States.

Through constant use the panel had become dirty and dog-eared. We are remaking it with fresh pictures and will then frame it. At the top will be attractive views of the Aurora plant and at the bottom, under the heading "The Fox—A River Beautiful," will be views of the river and pictures of holiday camping, fishing and boating—those uses for which rivers were made!

August 10—Hurrying home from the plant at 4 P.M. today, we jockeyed for position against a car entering our hairpin curve driveway, only to find it was our liability insurance engineer on his annual inspection trip. He is a conscientious fellow whom we like and he looked us over—but good! First he looked at the circulating water pumps in the furnace room and then requested that we place guards around the couplings. Since he had been inspecting our plant for years, we asked him why this request now? He replied that accidents occur in cycles and that recently there had been a large number of coupling accidents.

Substantiating his accident cycle theory, which our local insurance agent confirmed, he pointed out the large number of recent train wrecks and airplane crashes. On showing him the accident analysis pages in the 94th Annual Report of the Department of Water and Sewage at Detroit, Mich., he gave us the formula for calculating the frequency and severity indexes on which insurance premiums are based. He added that the Frequency Index for sewage plants is counted at 10. The formula given for the Frequency Index was: "total days lost, times 1,000,000, divided by total man-hours." The Severity Index was stated as: "total days lost, times 1,000, divided by total man-hours." He added that the price of a low accident rate is eternal vigilance on the part of all, especially the BOSS.

August 21—If the reader cares to refer back to THIS JOURNAL for November, 1944, he will find that the first story in the *Daily Log* (page 1227) is about tree roots. Today we are writing about the roots in that same sewer! In 1944 we paid $700 to clear the same kind of roots from the sewer that are pictured in Figure 2. This spring the cleaning operation had to be repeated at a cost of $816. The main stem of the two root masses shown was a good ⅝ in. in diameter and several bushels of such root clumps were removed. Although the sewer was laid with poured bituminous joints, after 15 years the roots forced their way through.

Failure to try copper sulfate as a remedy following the 1944 experience now seems a definite sin of omission,

especially after reading of the experience of Supt. Hood at the Ridgewood, N. J. sewage treatment plant (May, 1947 issue of *The American City*).

FIGURE 2.—$816 worth of roots!

Confirming this was the experience of Supt. J. W. McAmis of the Greenville, Tenn. plant related to us by Louis Birdsall of the General Chemical Company. In both cities tree roots were readily killed by periodically placing several pounds of copper sulfate crystals in the manholes of sewers that are subject to root growths.

Supt. Hood controlled tree roots in house connections by having a man call at each house and place a pound or two of the copper salts in the bowl of the toilets, dissolving and flushing it through. No damage to trees was ever observed. The tree roots die, the main stem breaks off and the roots withdraw from around the outside of the sewer.

We feel now that our error was in thinking of too elaborate preparation. All that seems required, according to experience elsewhere, is a small quantity of copper sulfate crystals that dissolve in a low flow so that sufficient concentration is obtained. It is imperative that there be some flow, even if such must be created artificially. Probably capillary attraction helps the copper to permeate the root masses. Copper sulfate is worth about $8 per 100 pounds. From now on there will be no more hesitation or delay here in putting copper sulfate to the test.

INTERESTING EXTRACTS FROM OPERATION REPORTS

CONDUCTED BY LEROY W. VAN KLEECK

It is disgraceful to stumble against the same stone twice.

—Greek Proverb

Report of Operation of the District of Columbia Sewage Treatment Plant for the Fiscal Year of 1946 *

BY RALPH E. FUHRMAN, *Superintendent*

Sedimentation Units Overloaded

Because of the overload on the existing sedimentation facilities, a contract for the design of four additional sedimentation tanks was entered into with Metcalf and Eddy, the original designers of the plant.

Settling Tank Ground Water Pressures Relieved

During the year an underdrain was installed around the sedimentation tanks for the purpose of relieving

* For last previous extract see: THIS JOURNAL, 18, 6, 1206 (Nov., 1946).

ground water pressures on the tank bottoms. With this underdrain it is possible to drain the sedimentation tanks for service operations at any time. (*Abstractor's note:* Where high ground water levels are known to exist, especially if deep tanks are used, another means of water pressure relief frequently employed is the installation of uplift valves which will open on the tank bottoms when they are drawn down and admit any ground water under pressure. These are generally built into the tanks at the time of construction.)

Digestion Tank Overload

The increasing population load was felt by the digestion tanks more than any other units in the plant. The original allowance of 1.75 cu. ft. per capita dropped during the year to about 1.1 cubic feet. As a result the scum blanket in all digestion tanks has increased to a serious depth. One tank has been taken out of service and complete removal of sludge and scum is under way. This appears to be the only way readily available to remove the accumulation of scum. In general the digesters' operating levels have been drawn down to receive raw sludge so that reliance upon the sludge and supernatant lines is eliminated.

Sludge Drying Facilities Planned

During the year the Department of Correction has further indicated informally the fact that more sludge is being shipped than can be used there. The ultimate solution to the problem appears to be in the installation of sludge drying and incineration facilities. This process would use waste sludge gas and produce a dried sludge that can be marketed to fertilizer interests. To this end funds were requested and appropriated by the Congress for the fiscal year 1947 to allow the design of these facilities.

Basic Operation Data

The cost of operation and maintenance of the plant for the year was $207,164. The mean sewage flow was 150.2 m.g.d. The settling tanks removed 44 per cent of the suspended solids in the raw sewage, and 25.3 per cent of the 5-day B.O.D.

Annual Report for 1945 of the Niagara Falls (N. Y.) Sewage Treatment Plant

By Edward J. Smith, *Superintendent*

This is a very complete report covering the historical aspects, design stages, and operation of this plant for the year 1945. Figure 1 is an illustrative section of the treatment plant. Table I is a summary of the operating data for 1945.

Historical

Work on the intercepting system was completed in June, 1937 and the treatment plant was completed in 1938. The plant was designed to remove a bacterial load rather than chemical load from the Niagara River, and comprises principally fine screening with chlorination.

Basis for Design

Gaugings were made of the flows from the eight different existing outfalls of the sewer system, and the average dry weather flow in 1933 was found to be 60 m.g.d.

An industrial survey at the same time determined that the 54 industrial plants in the city contributed about 40 m.g.d. of this amount, and furthermore that 30 m.g.d. of these wastes comprised unpolluted cooling and proc-

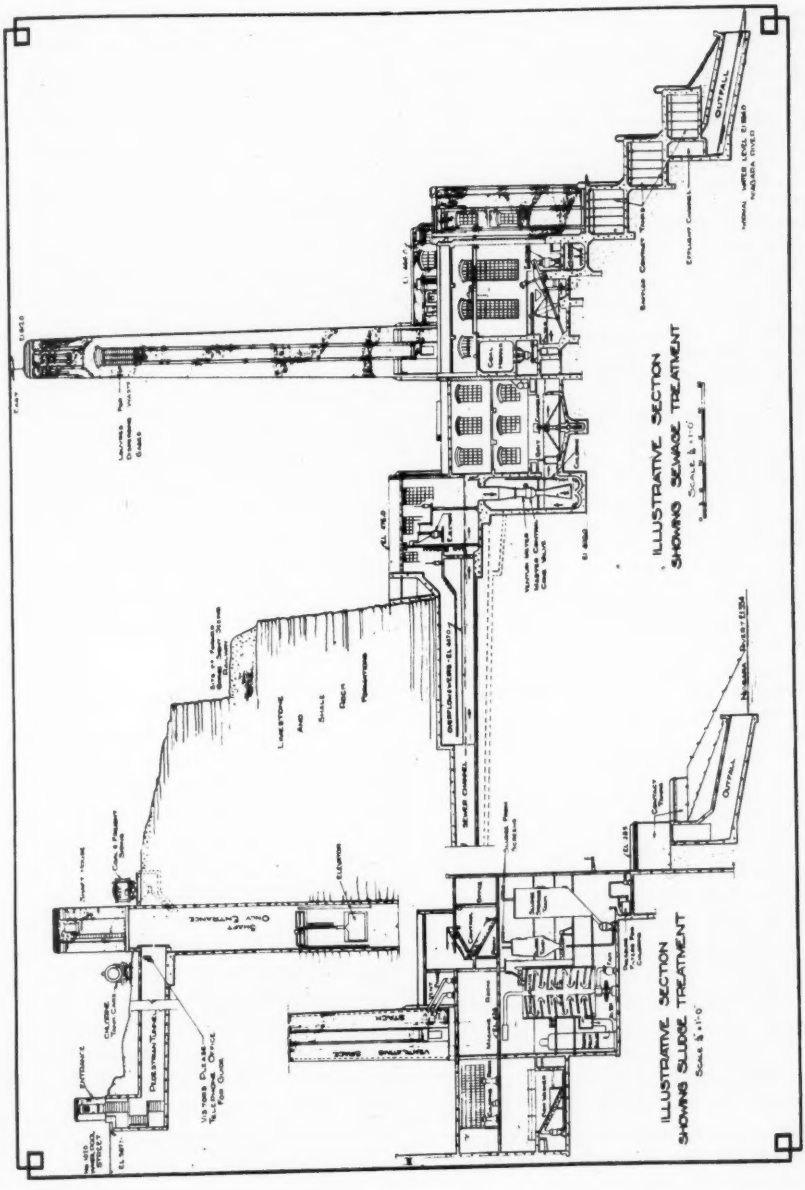


FIGURE 1.—Sections through the Niagara Falls, N. Y. sewage treatment plant.

TABLE I.—Summary of Operating Data for 1945 at Niagara Falls, N. Y.

Item	Average
Population connected, 1946 estimated	110,000
Total flow excluding storm flows (m.g.d.)	73.92
Grit (cu. ft. per m.g. sewage)	2.99
Screenings from coarse screens (cu. ft. per m.g.)	0.11
Fine screenings (cu. ft. per m.g.)	4.0
Fine screenings (per cent dry solids)	14.3
Chlorination, effluent content (p.p.m.):	
Ave.	3.4
Max.	280.0
Min.	0.2
Incineration:	
Lb. soft coal per ton dry solids	537.8
Fuel oil per ton dry solids (gal.)	3.2
Total tons screenings and grit burned:	
Wet basis	5,981.3
Dry basis	3,343.9
Per cent volatile in dry solids	40.6
Tons ashes per m.g.	0.05
Sewage analyses:	
Bar screened sewage:	
B.O.D. (p.p.m.)	52.1
Suspended solids (p.p.m.)	383.0
Fine screened effluent:	
B.O.D. (p.p.m.)	45.7
Suspended solids (p.p.m.)	359.0
Original plant cost	$2,945,000
Total maintenance and operating cost in 1945	$107,776.41
Cost per m.g. sewage treated	$3.45

ess waters that could be discharged directly into the river without treatment of any kind.

In order to reduce the size of the treatment plant, it was decided to adopt a dual system of sewage collection. One sewer is called the Diversion Sewer because its function is to divert the unpolluted wastes from the sanitary wastes. An interesting feature of the dual design is that it saves about $700,000 by reducing the size of the plant, to say nothing of the increased cost of operation, while the actual cost of the Diversion Sewer was only about $250,000.

Unique Collecting Tunnel

The existing sewer system consisted of eight separate outfalls into the river below the falls, several of which were deep tunnels discharging at nearly river level.

The collecting tunnel as designed was of necessity deep to take care of the deep outfalls. It ranges from 5 by 6 ft. to 8 by 9 ft. in cross section and is 17,500 ft. long, and from 100 to 150 ft. below the surface.

An interesting feature of design is the elimination of the troublesome regulators at points of interception. A simple double weir arrangement was installed at each outfall, which would intercept about twice the dry weather flow, and the real regulator designed in the plant as part of the plant structure where access and maintenance are easy. (*Abstractor's note:* Except in *very special* circumstances mechanical regulators in the sewer system are usually not worth their high cost and required maintenance. Invariably a simple weir will accomplish the purpose of storm flow diversion with both little initial expense and upkeep.)

Type of Plant

The plant site finally chosen was the only one along the entire gorge where there was the least possibility of squeezing in a plant. Various conventional plants were studied and discarded, due to excessive costs or lack of available areas upon which to locate the various units.

In addition to ordinary fine screening, provisions were made so that a thin layer of fine granular filter media such as coke, coal or sand could be superimposed on the screen surface to effect increased removals.

The plant includes the following units: bar screens mechanically raked; grease removal chamber; pre-chlorination mixing chamber; grit chambers; fine screens of the flat disc type; post-chlorination; contact tanks, sludge dewatering press; screenings incineration; outfall to Niagara River.

Grease Removal

During 6½ years of operation no grease has ever collected in the grease chamber, on chamber or channel walls, or on equipment. There has also never been any traces of grease or oil visible on the river surface at the outfall.

While undoubtedly there is discharged into the sewers the usual amount of grease, it is thought that the action of the ever-present chemical manufacturing wastes in the sewage forms fatty or organic acids, or an emulsion which may adhere to certain waste products such as paper fibre and similar organic matter and be largely removed by the fine screens.

Fine Screen Performance

Because of the inability of the city to segregate the non-polluting wastes from industries during the war, the plant screens have never been operated using the filter medium except during the acceptance tests. When the readjustment of waste discharges is completed and flows reduced to normal capacity, the screens will be operated with the supplementing filter. (*Abstractor's note:* Attempts to operate at Norwalk, Conn., with a fine screen filter medium were unsuccessful. However, at Norwalk screenings and media were not both removed at each screen revolution, a factor believed important in effective operation at Niagara Falls.)

Chlorination

The high chlorine content of the wastes from certain industries results in the need of only part time operation of the chlorinators. During summer chlorination (winter chlorination at the plant is not practiced), chlorine residual tests are run on both influent and effluent at least hourly. To facilitate sampling of the effluent a constantly running sample stream is installed in the laboratory. The effluent is pumped by a small triplex pump located so that samples will represent as near as possible the actual flow.

Summary of Sewage Treatment Plant Operations for the Year 1945 for the Greater Winnipeg Sanitary District, Winnipeg, Manitoba, Canada *

By D. L. McLean, *Superintendent*

Descriptive

The works operated by the District collects and treats the sewage from some 260,000 persons. Treatment includes screening through comminutors, primary sedimentation, sludge digestion, gas collection, elutriation of digested sludge prior to vacuum filtration, and sludge storage.

Suggestions Made by Superintendent for Use of Sludge as Fertilizer

Sludge cake is the earth-like residue left from the solids removed from the sewage after the objectionable part has been removed by methane bacterial digestion. The cake is a fiber-filled soil builder, rich in humus. It is equal to or better than well rotted barnyard manure for general use. The average analysis on a dry basis is as follows:

humus—35 to 40 per cent; nitrogen—2 to 3 per cent; phosphorus—1 to 2 per cent; growth hormones—present.

The ideal soil contains 20 per cent sand, 40 per cent clay and 40 per cent humus. Many local soils are deficient in humus which sludge cake can supply. It will break down a clay soil and close up a sandy soil, causing

* For last previous extract see: This Journal, **18**, 6, 1202 (Nov., 1946).

either to be more workable and to hold water longer for plant use. Most seeds will not germinate directly in sludge cake. Sludge cake is generally free from weed seeds and is practically odorless, although it may have a slight musty odor after a warm rain and before it has been worked into the soil.

Sludge cake may be used on lawns, flower gardens, trees and shrubs. It should not be used, however, in vegetable gardens from which vegetables are to be eaten uncooked. It is best to spread it over the area to be treated in the fall and to spade it into the ground in the spring. (*Abstractor's note:* If this is done in the temperate zones, as at Winnipeg, digested sludge should be safe for all crops the following spring. Let it be emphasized that no case of sickness has yet been traced to the use of digested sludge on garden soils. Parasitic worms may prove a problem in the South but have yet to be found in the North. The spreading of sludge on the garden plot the previous fall further removes any possibility of sickness traceable to its use.)

Sludge cake should not be mistaken for a balanced fertilizer. It is, however, well worth hauling and applying to the ground. It is free for the hauling.

Recommendations for application:

Garden and Flower Beds: 2 to 4 inches should be well spaded into the ground.

New Lawns: 3 to 4 inches should be worked well into the seed bed before seeding. As much as 1 cu. yd. per 100 sq. ft. may be used to advantage in proportions up to ⅓ to ½ of the soil volume.

Existing Lawns: Up to 1 inch may be raked into the grass roots and in bare areas (1 cu. yd. per 300 sq. ft.). (*Abstractor's note:* This sounds like a rather heavy application. Care must be taken that the grass is not smothered.)

Trees and Shrubs: Use as a "mulch" around roots.

Annual Report on the Sewage Treatment Plant of the City of Jackson, Michigan for the Fiscal Year Ending June 30, 1946 *

By A. B. Cameron, *Superintendent*

Swinging Supernatant Draw-off to Be Abandoned

Some troubles have been encountered with the swinging supernatant draw-off from the digesters and the swinging device will be abandoned in favor of a permanent overflow.

Comparison of Sludge Drying with Open and Closed Beds

During the past five years we have operated eight sludge drying beds of the same construction except that four of the beds were covered with the conventional type of glass covers as manufactured by the Lord and Burnham Company. Careful records have been kept regarding the number of dryings per year, moisture content, etc., and we have found that during this period the covered beds gave 165 dryings as against 152 dryings for the open beds. On the above basis we have decided that the covered beds could not be justified on a cost basis, as the insurance is high and the upkeep of painting, replacing broken glass and general maintenance ran into considerable money; further, they had reached the point where we were faced with a considerable expenditure for repainting and general overhauling. With the

* For last previous extract see This Journal, **19**, 4, 671 (July, 1947).

above in mind, we decided to sell the glass covers.

While this is of general interest to plant operators and engineers about the country, the results, of course, can be applied only to the type of sludge handled at Jackson. We feel, however, that the conclusions drawn at Jackson will apply to a great extent to any other plant; in fact, the writer had a similar experience at Fostoria, Ohio in the early thirties and has never been overly sold on the idea of the covered beds since the Fostoria experience. (*Abstractor's note:* Aside from reduced drying time there are three additional advantages for the covered bed. In locations near houses where appearance is important the covered bed will generally be acceptable to near-by residents where open beds might prove objectionable. Odors may be confined during the first 24 hours of wet drying by closing all sash. While odors seep out through cracks in the structure, moving air does not sweep over the sludge mass causing *carrying* odors as distinguished from *local* odors. Thirdly, operator comfort is a factor during cold or wet weather. Some operators actually plan sludge cake removal from enclosed beds on rainy days when outdoor work is unpleasant. Cost of installation and maintenance is, as Supt. Cameron points out, a big factor and there are many locations where open beds are completely satisfactory for sludge drying.)

Table II is a summary of the 1946 operating data.

TABLE II.—Summary of 1946 Operating Data at Jackson, Mich.

Item	Average
Connected population	50,000
Sewage treated, m.g. for year	2,577
Air consumed, million cu. ft. for year	1,665
Gas produced, thousand cu. ft. for year	21,808
Gas wasted, thousand cu. ft. for year	6,167
Dry solids removed, tons for year	2,282
Digested solids removed, tons for year	1,310
Cost of operation	$56,473.96
Cost per m.g.	$26.08
Suspended solids (p.p.m.):	
Raw	229
Final effluent	15
Mixed liquor	2,337
Reduction by plant (%)	94
B.O.D. (p.p.m.):	
Raw	155
Final effluent	4
Reduction by plant (%)	97
Dissolved oxygen (p.p.m.):	
Raw	1.3
Final effluent	6.7
Per cent of sludge returned	16
Sludge index	51
Reduction of solids in digesters:	
Total (%)	31
Volatile (%)	48
Air (cu. ft. per gal.)	0.7
Sewage flow (m.g.d.)	7.06
Raw sludge to primaries (1,000 g.p.d.)	30.7
Cu. ft. gas per capita per day	1.2
Lb. dry solids removed per capita per day	0.25
Grit removed (cu. ft. per m.g.)	0.57
Per cent CO_2 in digester gas	30
Dissolved oxygen in Grand River (p.p.m.):	
Above plant	8.0
Below plant	8.1
Alkalinity in digested sludge (p.p.m.)	2,764

Annual Report on the Worcester, Mass. Sewage Treatment Plant for the Year Ending December 31, 1945 *

By John H. Brooks, Jr., *Superintendent*

Type of Plant

This plant was placed in operation in 1925 and consists of grit chambers, bar screens, Imhoff tanks, dosing tanks, standard rate trickling filters, secondary settling tanks, and drying beds.

Works Operation in 1945

The acid sewage, which has caused

* For last previous extract see: This Journal, **18**, 6, 1210 (Nov., 1946).

difficulties with trickling filter operation throughout the war, changed in intensity of acid concentration immediately following V–J Day, August 15, 1945. The pH of the sewage became normal, or as it was prior to the war. Whether or not the abrupt change from low pH was harmful to the clogged condition of the filters is difficult to state.

In October, flooding of the filters was carefully done in an effort to clear them of clogging material. This was not successful. Resting of the filters did not improve conditions. Then cold weather prevailed; so that at the end of the year the trickling filters are in a partially clogged condition.

The iron content of the filter influent makes the use of chlorine a doubtful procedure to relieve clogging of the filter medium. Iron could be precipitated and cause increased clogging.

It appears that the best procedure is to await the normal unloading period during next May and June and trust that the more favorable pH of the filter influent will cause bacterial life to return to the filters and bring about filter unloading. The filters have not unloaded during the period of excessive acid condition of the sewage during 1943, 1944 and 1945.

The statement made in the 1944 annual report can well be repeated: "The trickling filters are in poor condition as a result of the character of the influent from early in 1943 (until August, 1945) and will not regain satisfactory or normal operating efficiency until the quantity of acid discharged into the sewage is greatly reduced. Following this, the filters will have to clear themselves of all clogging material by proper operation accompanied by favorable warm atmospheric conditions."

All other units of the sewage treatment plant are operating in the usual manner. (*Abstractor's note:* Since this report has been released, it has been decided that major renovation of the trickling filters will be required before filter operation can be resumed.)

Plant Understaffed

It is unfortunate that the Worcester sewage treatment works, with its prewar record of successful operation, should continue to struggle with insufficient operating personnel and funds. As a consequence thereof, there exists dissatisfaction with the working conditions and hours among the small number of employees. Moreover, it is impossible to maintain efficient operating conditions and facilities; the physical condition of the property has been neglected due to the lack of sufficient operating funds and labor.

Reluctance to correct these conditions could be appreciated if operating costs were exorbitant. Such is not the case. It is believed that no other sewage treatment plant in this country is giving complete treatment to the sewage, including 3 m.g.d. of industrial waste liquors, from a population of 200,000 persons for the sum of $6.15 per million gallons or 30 cents per person per year.

The excellent past achievements of Worcester in treating its industrial sewage should be continued. This cannot be accomplished unless the operating funds and personnel are increased.

MOISTURE CONTROL IN MASONRY MAINTENANCE*

By R. D. Thayer

Waterproofing Contractor, Detroit, Mich.

Deterioration of buildings by the elements has been one of the big problems of the construction field since man changed from tents and caves to masonry buildings. Chief among the problems has been the breaking down of different types of masonry caused by the permeation of moisture into and through such construction. The word "through" is used advisedly as will be mentioned later.

Up to the turn of the present century, damage by moisture, as a separate factor, had not appeared so very important or serious; but with the common acceptance of concrete as a major construction material it soon became evident that some type of admixture material could or should be added to the concrete mass to reduce capillarity.

With the arrival of the building boom of the Twenties, cement had become an accepted major building material to such an extent that the cement manufacturers were busily engaged in promoting the use of cement mortars for brick construction. Gradually cement mortars largely supplanted lime mortars, and so continued the trend toward the use of cement in construction, with the so-called "cast stone" being probably one of the weakest features of this period. Thus was born the necessity for waterproofing services to combat the disintegration in all types of masonry construction, from the top of the tallest towers to the bottom of the deepest excavations.

In order to present this subject clearly, it is being divided into four parts: (1) Evidence, (2) Cause, (3) Correction, and (4) Preventive Measures. Evidence is placed before Cause deliberately, as in most cases there is no thought of Cause until the Evidence is very plain.

Under the heading of Evidence are included some of the more noticeable features of disintegration such as the spalling and cracking of concrete; spalling and dusting of brick; the efflorescence on brick or tile; staining of stone, particularly at joints and the underside of lintels, cornices, and other projections; and the disintegration of mortar joints.

The spalling of concrete on exterior surfaces is much more common in the cold climates than in the warmer sections due to the expansion of the moisture which, in freezing, gradually breaks down the surface of concrete masses. In the southern climates, however, disintegration due to the extremely rapid temperature changes presents nearly as serious a problem as freezing does in the colder climates. This is evidenced by the frequent breaking down of surface textures on south and east exposures where buildings have had no protection from the morning sun. These exposures contract considerably during the cool night hours, and then are subjected to sudden expansion by the direct rays of the hot morning sun. Even in the northern climate of Michigan, buildings have shown greater deterioration on the south and east sides from these causes than on the north and west sides which are entirely exposed to the prevalent storms of Michigan winters.

Cracks in concrete are very often caused by the oxidation of reinforcing rods and their resulting expansion. This type of cracking is also commonly found to be due to the flanges of embedded steel sash; angles or channels

* Presented at 22nd Annual Conference, Michigan Sewage Works Assn.; Jackson, Mich.; May 14, 1947.

embedded to hold door-frames; I-beams, H-columns, and lintels incased in concrete; supports for motors, tracks, etc. These cracks must not be confused with those due to expansion and contraction, or those due to structural stress.

Moisture in brick is often evidenced by a white deposit on the brick surface, which is known as efflorescence. If on the exterior, this is due to either (1) extremely high humidity inside the building with the heat of the sun drawing such moisture through the wall, as mentioned in the opening paragraph; or (2) the moisture penetrating from the outside, then being drawn out by the sun. This can also work in reverse if the temperature inside the building is high and the humidity lower than the normal outside humidity. This is often shown inside by a deposit of fine white powder on the plaster, particularly around the windows.

Another place where efflorescence is often evident is on an unprotected parapet wall. Whatever the circumstances are, efflorescence is proof that moisture permeating the masonry is dissolving some of the free salts, is bringing them to the surface by capillarity, and is depositing them as a warning that disintegration is taking place.

In the case of common brick, efflorescence will very soon cause a dusting or spalling off, which, if allowed to continue, may mean the replacement of many brick. This is not an even disintegration, due to the difference in texture and burning of brick. It is not uncommon to find a beautiful bent grass lawn, upon which much money has been spent, made unsightly after a rain storm has transferred the disintegrated brick surface from the building walls to the lawn.

Spalling of face or glazed brick takes a different form, the more usual pattern being that the moisture penetration is much greater into the flat side of the brick than into the face. Moisture thus entering from the mortar joints penetrates into the body of the brick and, as the face of the brick is less porous, is partially trapped. The disintegration which ensues, together with the freezing, will eventually cause the surface of the brick to break off, usually about a half inch back from the face. This not only results in unsightly appearance but also creates a safety hazard for anyone passing or working below. Common examples of this can be observed on some of the enameled brick gas stations and hamburger stands which are so common along main highways.

The rusting of reinforcing rods due to the penetration of moisture is particularly bad where the concrete mass is continually exposed to high humidity, such as the concrete immediately adjacent to aeration or sedimentation basins of a sewage treatment plant. Disintegration of concrete is extreme wherever the water level fluctuates. This is especially noticeable in the tail-race and penstocks of power plants, where the water flow is intermittent. Probably it is also apparent in many parts of sewage disposal plants. Any deposit of inert matter, however, will tend to reduce this action and is a plain evidence of the need for waterproofing of all surfaces where moisture is prevalent.

Experience has shown that the oxidation of iron embedded in concrete is very slow where such concrete is below the permanent water line because the amount of oxygen available is not sufficient for rapid development of rust. Another very pronounced example of reinforced concrete deterioration is the fast action of moist atmosphere and hot sunshine upon the balusters, hand rails and girders of highway bridges. This can be seen on any road.

At the present time the spalling of concrete on above-ground structures is becoming a serious menace to the

public. The Department of Building and Safety Engineering for the city of Detroit has ordered an inspection of the concrete, cast stone, stone and brick projections of many of the large downtown buildings and, in many cases, has condemned parapet walls and overhanging projections as unsafe. Investigation indicates that most of these buildings were constructed during the Twenties, which would be evidence that cement mortars of that time were more or less faulty. To substantiate this is the fact that many leading firms which strive for quality in masonry construction are incorporating more lime in brick mortars than was used a few years ago.

This reference to mortar mixes brings up the most important part of this discussion: methods for correction and restoration. Present waterproofing materials are divided mainly into the following types: admixtures, surface materials, and penetrating materials.

Admixtures undoubtedly should be used in original construction. They are, however, very useful in concrete restoration of exteriors, for by the proper use of these, spalled and broken areas are more satisfactorily repaired.

Unless some compensating material is used in the building-up of patches of the type needed where reinforcing bars have broken off heavy pieces, the concrete mass used for replacement is very apt to shrink sufficiently in curing to cause some fracturing of the bond between the old surface and the new. Metallic type admixtures are one of the most satisfactory types now available. This is somewhat anomalous, since the oxidation of the embedded reinforcing metal has caused the original trouble. The oxidation products of the fine particles of the metallic admixture will expand sufficiently to compensate for the shrinkage of the concrete during the curing process.

While it is not impossible to do restoration work without admixtures, by using them the ordinary mechanic is able to do more satisfactory and efficient work; results are more uniform; and costs are less, under most conditions.

It is important to know that if the restoration work is followed by painting, metallic waterproofing materials will bleed through unless a special type of paint is used, such as one of the rubber base or resin product paints. To obviate the necessity of using these special paints, which are quite expensive, it is satisfactory to use some of the fatty acid admixtures in place of the metallic type. This not only forms a very good foundation for the ordinary oil paints, but reduces capillarity to a very pronounced degree.

Another phase of maintenance work in which admixtures have a very definite value is in the prevention of water penetration by hydrostatic pressure, such as in tunnels, pits, tanks, and basements where the concrete walls are porous or have developed cracks through stress, shrinkage or settlement.

In considering surface types of waterproofing, there is a wide variety of ideas or, more accurately, sales talk, for the public has lately been deluged by advertising in magazines and newspapers. Probably all, or nearly all, of these so called "cure-alls" have merit but unless applied by "Super-man," will not meet the expectations of the purchaser.

One of the original surface types of waterproofing materials which is still commonly used, with more or less satisfactory results, is the cementitious coating. This material is marketed under various trade names. All are water-repellent in varying degrees.

Moistureproofing rather than waterproofing is needed, however, to really preserve masonry structures. For although a surface coating may stop a flow of water, it may still allow the penetration of moist air by capillarity

or, under some conditions, vapor pressure. In an inclosed chamber, whether this be a tank or a room, if the temperature is raised the air automatically expands, increasing the vapor pressure. If the sun's rays are striking directly on the exterior of the wall of such tank or room, moisture will penetrate "through" the wall. Consideration of these facts will explain why moisture control rather than mere waterproofing is needed.

One reason why surface types of waterproofing have remained popular is because they furnish a cheap decorative coating with some waterproofing qualities. These should be classed as decorative coatings rather than waterproofing materials and are not satisfactory where protection is the prime requisite. Surface coatings are one of the most profitable coatings which contractors can apply. This undoubtedly is the main reason for their continued popularity.

While discussing surface type coatings, some mention should be made of the membrane and asphalt plastic types. Use of these is advantageous under some circumstances, such as for roof slabs of tunnels and a few other similar surfaces; also as a breaker strip between foundations and walls. For the better class of work, however, thin copper sheeting is becoming increasingly accepted as a more substantial and safer installation.

Penetrating types of coatings are classified as colorless, semi-colorless, and opaque penetrants. The colorless types are the only ones feasible for attractive brick, tile, and stone structures for which the exclusion of moisture is necessary and maintenance of the original surface texture and appearance is requisite. Since few materials can be incorporated in a colorless water-repellent, these products usually need replacing more often than the heavier-bodied types.

A combination of penetrating and surface type waterproofing materials is satisfactory where conditions warrant or allow their use. This is especially true on concrete, cast stone and stucco surfaces. For stucco surfaces where crazing is very pronounced and also for cast stone surfaces where the deterioration is quite advanced experience indicates that a combination of a penetrating material and a plastic coating, of the oil rather than asphalt type, makes a satisfactory moisture-tight coating. This is particularly true on a stucco surface where the movement which has caused the crazing of the surface will break any ordinary paint type of coating because of the rigidity of such materials. The oil type of plastic coating, if applied heavily, has sufficient elasticity to withstand this surface movement.

The waterproofing industry is looking forward with a great deal of hope to the development of more efficient materials, possibly in the plastics line, than are presently available. Only this year an experimental waterproofing job for a large Detroit industrial firm was finished, using a resinous material developed by one of the leading waterproofing manufacturers and the engineers of the industrial firm. While this compound was originally planned as a material to withstand alkalies, acids and solvents, it also proved to be very water repellent.

Another recent discovery of great promise is that of the inorganic silicones. These silicones are being developed to produce fluids which will withstand extremes of cold and heat from −60° F. to 600 or even 900° Fahrenheit. Limited quantities of these new materials are now available commercially. Results of tests on masonry indicate that existing waterproofing standards may be entirely revised and that for the first time it may be possible to approach moisture problems with the thought of using a colorless inorganic repellent.

TIPS AND QUIPS

Lewis Process at Lebanon, Ohio

In the course of a recent trip through southern Ohio, advantage was taken of the opportunity to visit the sewage treatment plant at Lebanon, which is the first and only operating installation of the "Lewis Process." This is a proprietary chemical precipitation process, for which better results are claimed than those normally expected from this type of treatment. The claims are controversial in at least one state in which the process is being exploited.

The sewage at Lebanon, averaging about 0.5 to 0.75 m.g.d., is above average in strength because of cannery wastes. The raw sewage B.O.D. ranges from about 250 p.p.m. to more than 600 p.p.m.

Operator Fred H. Zimmerman extended a cordial welcome at the time of our visit and spared no effort in showing us through the plant and in answering our many questions.

After passage through a comminutor the incoming sewage is dosed with ferric chloride (about 110 lb. per m.g.) followed by an 8-minute rapid mix, then dosed with lime (about 2,500 to 3,000 lb. per m.g.) and Cottrell dust (about 400 to 500 lb. per m.g.) at a second rapid mixing tank. Ferrous sulfate (about 700 lb. per m.g.) is then applied at a third tank in which the stirring is much slower. The flocculation occurs at about pH 10. Cottrell dust, incidentally, is a fine dust that is produced in the course of cement manufacture.

The flocculated sewage is submitted to sedimentation, first in a rectangular primary unit equipped with sludge collectors and affording 1.85 hours detention at 561,000 m.g.d., then in series to an old Imhoff tank. The effluent channel of the latter unit is fitted with a perforated pipe aeration system for providing dissolved oxygen to the treated sewage before discharge to the stream.

According to Operator Zimmerman, the treatment effects about 70 to 75 per cent removal of B.O.D. and about 85 per cent removal of suspended solids. These results are in line with the findings of the Ohio Department of Health, which made a series of ten 12-hour tests of the plant in 1940. The plant effluent, of course, despite the 6 to 8 p.p.m. of D.O. introduced by channel aeration, is not of sufficiently good quality to prevent objectionable conditions in the outlet stream during low summer flows.

The process produces a large quantity of dense, biologically inactive sludge, estimated by the Ohio Department of Health on a dry basis at four to five times the amount of suspended matter normally carried by domestic sewage. Facilities for handling and disposing of sludge are rather primitive, comprising only two small sludge drying beds and several undrained lagoons. The only storage is that available in the lower part of the Imhoff tank. Dewatering of the sludge takes place very slowly, even at the conventional drying beds.

Operating costs at the Lebanon plant are high, with chemical costs alone amounting to $25 to $35 per m.g. The regular operating staff at present consists of two men.

Our reaction after visiting the plant was that it is accomplishing about what one would expect of chemical precipitation but at a chemical cost that is well above the average for conventional chemical precipitation plants. Moreover, a sludge dewatering and disposal problem remains to be solved at the Lebanon plant.

Something New

We do not ordinarily give space here to new equipment releases by

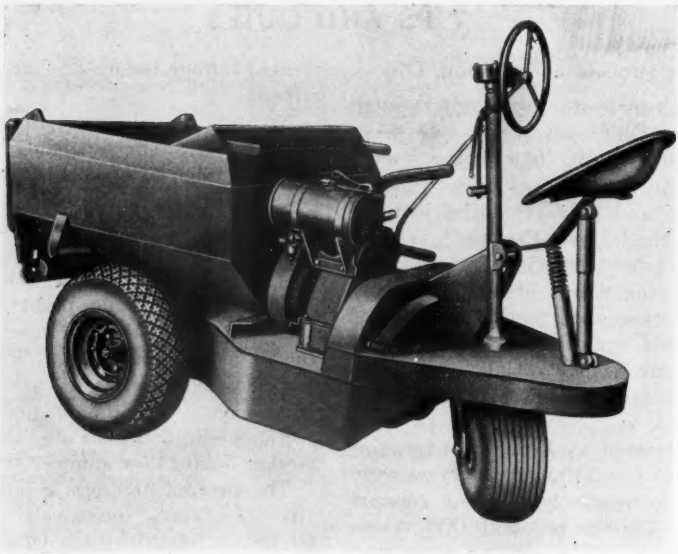


FIGURE 1.—The "Scootruk."

manufacturers, but the "Scootruk" (Figure 1) appears to be an item which might be of particular interest to operators.

The Scootruk is described as a miniature dump truck having a 1-ton load capacity and capable of travelling 15 m.p.h. The "mechanized wheelbarrow" weighs only 1,000 lb. and its special airplane type tires are said to carry it anywhere—even on loose sand. The edge of the load bucket is only 34 in. above the ground.

The machine is powered by a 6-h.p. air-cooled gasoline engine and is equipped with 4-speed transmission. Steered by the single tail wheel, the Scootruk is highly maneuverable.

It would seem that the Scootruk might find excellent application in small sewage plants where sludge bed cleaning is often carried out as available time permits. In larger plants it might be an excellent multi-purpose vehicle.

Name of manufacturer will be furnished on request.

A Successful Recovery

Every sewage works superintendent has at one time or another been asked if he could possibly retrieve a watch, a ring or other valuable article that was lost to some heartless plumbing fixture. Reports of actual recoveries of this kind are indeed rare, and the *Southwest Water Works Journal* (June, 1947) describes one successful effort at New Orleans, La.

Object of the search was a $3,000 diamond ring. The procedure used by Engineer N. M. Redmond, who supervised the sewer cleaning crew, is set forth as follows:

"Using a hydraulically operated sewer cleaning device the work gang placed the device in a sewer opening and screened off the sewer at the bottom of another opening with sand bags blocking off the sewer bottom.

"Water pumped with a pressure of 101 pounds per square foot and channeled through the sewer cleaning device forced the ring which had lodged in the sewer to the bottom of the manhole. There, while

the water flowed away, the ring's progress was stopped by the sand bags and it was retrieved from the bottom of the manhole."

"Clean Waters" Scores

In its first year the moving picture "Clean Waters" has been shown nearly 3,000 times and has been seen by an estimated 157,000 persons. Produced by the General Electric Company as a medium of public education, the film is proving to be a valuable tool in the promotion of sewage treatment projects.

A recounting of accomplishments of "Clean Waters" lists its successful use in sewage works bond issue campaigns at Spokane, Wash., Santa Cruz, Calif., Modesto, Calif., Joplin, Mo. and elsewhere. Nineteen state pollution control agencies have purchased copies of the film for use in their stream sanitation programs. Showings have been given before hundreds of civic bodies of all kinds.

How many times has "Clean Waters" been shown in your town? Do not fail to make use of this valuable molder of public opinion, whether or not your community is already served by a sewage treatment plant!

Data from Dayton

An hour is just not long enough to constitute a "visit" to a sewage treatment plant, especially at such an interesting one as that serving Dayton, Ohio. As it was, we encroached a bit on Supt. Lloyd C. Huffman's lunch hour, though he did not seem to mind.

Handling 35 m.g.d. of sewage, the plant is somewhat overloaded on the basis of accepted criteria, yet it effected an average B.O.D. removal of 87 per cent in 1946 while discharging an effluent with a B.O.D. of 27 p.p.m. This was done at an operating cost of $7.63 per m.g. treated.

Digestion capacity is now being augmented by the installation of two 85-ft. digesters, to be heated by P.F.T. heat exchangers. Further expansion is also needed in primary sedimentation, trickling filters and sludge dewatering facilities.

An interesting procedure is used here in providing primary treatment by Imhoff tanks with supplementary separate digesters. The practice is to pump the scum from the gas vents of the Imhoff tanks (about 60 per cent volatile) to the heated separate digesters. The digested sludge is then returned to the lower compartment of the Imhoff tanks, whence it is drawn to the drying beds. This routine has been found to yield the best digested sludge from the standpoint of drying time.

Pumping of Imhoff tank scum to the separate digesters, incidentally, is accomplished by two Nash ejectors, each having a pot capacity of 500 gallons. These units have given trouble-free service for about 9 years.

The cluster of twenty 165-ft. trickling filters at Dayton is quite a sight. Loaded at 475 lb. and higher per acre-foot per day, these units are giving excellent results. Operators of trickling filters who have experienced trouble with the snail shells that are often disgorged in quantity will be interested to know that the problem has been solved at Dayton by returning the final settling tank sludge to the raw sewage channel ahead of the grit chambers. The bulk of the shells are deposited with the grit, relieving the Imhoff tanks and digesters of an unwelcome item.

Industrial and waste crank-case oils are believed largely responsible for the difficulty at the Dayton plant of securing good drying of sludge either on the open or glass-covered beds. A special tank truck has been equipped to collect such waste oils, on a schedule, from known sources. The oil is used as fuel at the city garbage incinerator.

Since 1939 a portion of the Dayton sludge has been heat dried for sale as fertilizer, a 25-ton per day, Nichols-

Herreshoff, multiple hearth furnace being used for this purpose. Of the 1947 production, 500 tons have been contracted for sale at $11.50 per ton and 1,000 tons at $8.50 per ton.

Few scars remain of the devastating gas explosion that occurred at the Imhoff tank pipe gallery in 1938. The incident has not been forgotten, however, as evidenced by the precautions taken to prevent a similar accident.

The superintendent of the Dayton plant has varied responsibilities. In addition to the sewage treatment plant, Supt. Huffman has under his direction about 550 acres of farm land, several rental properties, including a fish hatchery, and the municipal garbage incinerator. Versatile as he is, he found it necessary to extend his talents last spring when he had to give personal attention to the purchase of a bull that was needed at one of the farms!

What? No Effluent?

John D. McDonald, engineer of sewage treatment at Springfield, Mass., gave an interesting recital of water supply and sewage disposal practices in Korea at the joint meeting of the New England and New York State Sewage Works Associations last May. Following is his description of one Korean plant:

"The only large scale sewage treatment plant was at Pusan, Korea. There is no water-borne sewage in this city of about 300,000 but the house-to-house collection is made by city owned collection wagons and the wastes are hauled to the treatment plant. At the plant, farmers come and take any part of the night soil they want as it was delivered, and the remainder is sent to the first of a series of four rectangular digesters. These covered digesters are built on a hillside and terraced so that the drawoff from the first unit entered the top of the next and so on. No effort was made for gas collection.

"The digested sludge from the fourth and last tank is drawn off periodically and taken by gravity through a 12-in. cast iron pipe for a distance of 4 miles to a sludge drying bed near the sea. The underdrains from this bed collect all the liquid in a concrete tank. Farmers in the neighborhood take this liquid as desired for their gardens, and the remainder is piped a distance of ½ mile in a 10-in. concrete pipe supported on pillars, aqueduct style, to a wharf where barges dock. By opening a valve the barges take what they want of the sludge bed drainage.

"The dried sludge is spread on the farms each fall and plowed under. At various times, the sludge drying beds are bypassed and digested sludge is being piped directly to the farmers' barges. The sludge looked and smelled like it was well-digested."

A Handy Tunnel

Operators are the best critics that the consulting engineers have, and seldom is an operator reluctant to show the parts of his plant that he would have built differently. So when we read, in Supt. David Backmeyer's 1946 report on the Marion, Ind. plant, a *commendatory* remark about a design detail, it reminded us of the "man bites dog" example of what constitutes news.

Describing the need for dismantling to clean the piping that carries raw sludge and ground garbage in the Marion plant, Backmeyer states "We are fortunate that this 200-ft. or 6-in. pipe is in a tunnel where it can be reached for such rodding-out jobs." Consoer, Townsend and Associates, designers of the Marion plant, may take a well-earned bow!

The ground garbage carried in this pump suction line is blamed for the grease and scale that accumulated on the inside. To give an idea of the amount of the deposit, the report states that 4 lb. of it was removed from one 6-in. ell.

Wordplay

The "editorialette" opening *The Operators' Corner* of the March, 1947

JOURNAL suggested that the six letters of the word "safety" connoted Saneness, Alertness, Foresight, Equipment, Teachings and You (the personal element). Prof. Don E. Bloodgood, in the May, 1947 issue of Purdue University's *Sanitary Engineering News,* points out that the same letters can represent "Sense Always Favors Every Tender Young'un."

Put it any way you like, so long as you keep in mind that "*Severe Accidents Follow Every Thoughtless Yokel!*"

Editorials

THE CONCURRENT MEETINGS IN RETROSPECT

This is a sequel to the pre-convention editorial (July issue, page 681), which was intended as an analysis of the anticipated advantages and disadvantages of the concurrent AWWA and FSWA annual meetings at San Francisco, so that those planning to attend would have some advance idea of the affair. Interest in the outcome of the experiment has been widespread, justifying further appraisal of the actual results.

By and large, the meetings were indeed a success, whether considered separately or jointly. Since there was no precedent it is only natural that some mistakes were made, but these were of such nature that they all could be corrected another time. If the "double feature" is ever repeated there will certainly be modifications in registration requirements and procedures, and in the scheduling of social events, these being two details which were responsible for some minor complaint.

The only criticism that was at all general in its expression was "that there was too much going on at one time." Termed the "three-ring circus aspect" in our preview of the meetings, this factor is not readily correctible. It is a major disadvantage of a dual event, whether held as joint, concurrent, combined or consecutive meetings. Here is the main argument for separate meetings of the two national organizations under ordinary circumstances. It has previously been emphasized that the circumstances leading to the decision on the concurrent conferences at San Francisco were definitely out of the ordinary.

Registration data are interesting. The total registration for both meetings was 1,955, including 1,426 men and 529 ladies. Of the men registrants, 311 recorded at the Federation desk, 714 at AWWA desk and 401 registered for both meetings as manufacturers' representatives. Of the non-manufacturer registrations, it is conservatively estimated that about 125 were duplicated with both associations. On that basis the actual combined attendance comprised about 1300 men, of which 30 per cent were manufacturers' representatives. The Federation's registration of 964 was the highest ever recorded, but it must be admitted that the requirement that all manufacturers register for both meetings greatly favored this total.

The Presidents' Reception and Dance held on the first evening and the Gala Entertainment held on the second evening of the meetings, both of which were joint social events, were eminently successful from every standpoint. The ladies' tea and fashion show, tour and luncheon-bridge events, also arranged as joint functions, were likewise highly successful, although the attendance of the tea and of the luncheon-bridge was only about half of that anticipated.

The technical program featured by the Federation in Polk Hall was certainly one of the best to date, and has elicited much favorable comment. Attendance of these sessions was very good, comparing quite favorably with AWWA sessions being held simultaneously.

At least one commentator has noted an opinion that "the AWWA activities overshadowed the conference . . ."—a conclusion with which the writer does not agree except with respect to one event. This exception—the Annual Federation Dinner—was the unfortunate buffer in the overfull schedule of evening social events. Held on the evening preceding the AWWA dinner, only 254 tickets were sold in the face of plans for a sellout of 600. The event was distinctly successful as conducted by President Friel, however, despite the disappointing attendance.

As expected, the exhibit arranged by the WSWMA was the most comprehensive showing of water and sewage works equipment and supplies in history. Only a dual meeting could have attracted the number and caliber of exhibits that were displayed.

Mention must be made of the fine work of the various convention arrangement

committees, all of which were required to solve unusual complications inherent to the conduct of two meetings at once. The arrangements for transportation, housing, general entertainment, ladies' entertainment, meeting room details, etc., all were handled admirably by joint committees, without the benefit of precedent experience. California hospitality also contributed measurably to the success of both meetings.

The concurrent meetings experiment was unquestionably worth while, and both AWWA and the Federation were indisputably served better by the arrangement than would have been the case if an attempt had been made to hold the two 1947 conferences separately in California, only three months apart. The experience proved conclusively that the two national bodies, although quite different in their organizational structures, were able to adapt themselves to the joint undertaking. Major credit for this is due AWWA Secretary Harry Jordan, who strived incessantly to avoid possibility of the Federation's being overwhelmed by the larger water works group.

The San Francisco trial has shown that the AWWA and the Federation can combine their annual meetings successfully if future circumstances ever indicate such an arrangement to be more desirable than separate meetings. It is believed, however, that the frequency of these dual efforts should not be greater than once in eight or ten years.

THE JOB AT HAND

The magnitude of the needs of the nation in municipal sewage collection and treatment facilities is strikingly disclosed in the results of the latest survey by the U. S. Public Health Service. More than 80,000 miles of sewers, 12,000 new sewage treatment plants and extensions to 1,200 existing plants must be built in order to fulfill present sanitation requirements. Complete sewage works are needed in 9,100 communities.

The cost of these facilities is estimated at 3.7 billion dollars, of which $360,509,000 or 9 per cent of the total is represented in projects that are ready for immediate construction. An additional $908,048,000, or 24 per cent of the total, is currently in various stages of planning.

Meanwhile, the F. W. Dodge Corporation reports a sharp gain in public works construction in the face of a general slackening in the building industry. Some of the excess costs resulting from material shortages, low labor productivity, abnormal overtime and bonus wages, etc., are beginning to disappear. In short, the buyers' market in construction is on the way back.

Let us not forget, however, that the real job starts when the contractor has finished. The new sewers and treatment plants will not render the intended service without competent operation, and the training of the thousands of operators who will be needed represents a substantial challenge.

The Federation and its regional units have their work cut out. We must intensify our research efforts so that the utmost in efficiency and economy may be realized in the new works. We must also continue the constant search for improved and simplified operation techniques, while emphasizing the basic training of those now engaged in plant operation. The operators of today who have demonstrated their competence must be counted on to teach the operators of tomorrow.

Proceedings of Member Associations

FLORIDA SEWAGE WORKS ASSOCIATION

5th Annual Meeting

Gainesville, Florida, June 9–14, 1947

The Fifth Annual Meeting of the Florida Sewage Works Association was held on the University of Florida campus at Gainesville on June 9–14, 1947. The meeting was a part of the Fifteenth Annual Florida Short Course on Water Supply and Sewage Treatment, of which the Florida Sewage Works Association is a joint sponsor with the Florida Section of AWWA, the Florida State Board of Health and the Florida Water and Sewage Works Operators Association.

The principle underlying the development of the short course program is to train the operator to do a better job by instructing him in standard methods and giving him actual practice in laboratory procedure. The sponsoring organizations have established a committee charged with the responsibility of developing not only the annual short course and conference but also other methods of making training available to operators throughout the year.

An interesting description of the experimental pilot plant constructed by the Industrial and Engineering Experiment Station at the University of Florida was given by Prof. D. L. Emerson, and was followed by an inspection trip through the plant.

J. R. Hoy and E. K. Phelps, both representing the Wallace and Tiernan Company in Florida, conducted demonstrations on the installation, maintenance and operation of various types of chlorinators.

C. F. Garland of the Bureau of Sanitary Engineering, Florida State Board of Health, presented an interesting discussion on elementary arithmetic of sewage treatment.

James Adams of the Solvay Process Company, Syracuse, N. Y., conducted a demonstration on the handling of chlorine cylinders and on related safety procedures.

Wilson T. Calaway, assistant in sanitary research in the College of Engineering at the University of Florida, and S. W. Wells, Bureau of Sanitary Engineering of the Florida State Board of Health, presented an interesting paper on "Water and Sewage Bacteriology."

The Federation was well represented at this meeting by President F. S. Friel and Vice-President George S. Russell, both of whom participated in the program. Mr. Friel made an address on "Public Relations," stressing the importance of activity at the local level. Mr. Russell spoke on the topic "Sewage Works Nomenclature," in which he emphasized the proper usage of terms that are commonly misused.

At the annual business meeting of the Florida Sewage Works Association, held in the Hotel Thomas at Gainesville, action was taken to authorize Federation Director David B. Lee to invite the Federation to Florida for its 1951 or 1952 annual convention.

By recommendation of the Executive Committee, Prof. Earle B. Phelps, formerly of Columbia University and now at the University of Florida, was elected the first Honorary Member of the Florida Sewage Works Association.

Albert L. McGregor of Boca Raton was elected President of the Association for 1947–48; J. R. Hoy, Jacksonville, was elected Vice-President and Chesley F. Garland, Jacksonville, was elected Secretary-Treasurer. B. F. Borden was elected FSWA Director for a three-year term expiring in 1950.

C. F. GARLAND,
Secretary-Treasurer

MARYLAND–DELAWARE WATER AND SEWERAGE ASSOCIATION

20th Annual Conference

Washington, D. C., May 15–16, 1947

The Twentieth Annual Conference of the Maryland-Delaware Water and Sewerage Association was held at the Hotel Hamilton in Washington, D. C., on May 15–16. Registration totaled 195 members and guests.

The program started with an address of welcome by Harold A. Kemp, Director of Sanitary Engineering of the District of Columbia. Informative papers on sewage works topics presented in the technical sessions of the meeting included:

"Improvements in Water Supply and Sewage Treatment at Annapolis and Frederick" by Roy Ritter, Partner, Whitman, Requardt and Associates, Consulting Engineers, Baltimore.

"A Program for the Elimination of Cross Connections and Plumbing Defects" by William H. Cary, Director of the Public Health Engineering Bureau of the D. C. Health Department.

"Institutional Sewage Treatment" by Graham Walton, Sanitary Engineer of the Federal Bureau of Prisons.

"Chlorine Supply for the Future" by C. M. Holt, Manager of Chlorine Sales of the Diamond Alkali Works.

"Treatment of Linoleum Wastes" by W. Y. Irwin, Development Department, Congoleum-Nairn, Inc., Cedarhurst, Md.

"Sewage Disposal Systems" by R. VanDerwerker, Sr., Sanitary Engineer, Federal Public Housing Administration.

"Sludge Digestion and Operating Troubles" by P. D. McNamee and J. E. Rice, Chemist and Assistant Chemist, respectively, of the D. C. sewage treatment plant.

A general open forum for plant operators concluded the technical program.

At the business meeting a resolution was passed supporting the Interstate Commission on the Potomac River Basin's request for funds from the Federal Government.

Dr. John C. Geyer announced that Clarence E. Keefer of the Bureau of Sewers, Baltimore City, had been selected to receive the Federation's 1947 Kenneth Allen Award for "outstanding service in the sewage works field, as related particularly to the problems and activities of the Maryland-Delaware Water and Sewerage Association."

FSWA President F. S. Friel spoke at the business meeting on "The Growing Federation," reporting on recent accomplishments, the current program, and future plans of the international organization.

Officers elected to serve during 1947–48 were:

President: J. W. Engle, Washington, D. C.
First Vice-President: R. C. Willson, Hagerstown, Md.
Second Vice-President: A. A. Bailey, Baltimore, Md.
Secretary-Treasurer: E. Virginia Gipe, Baltimore, Md.

E. VIRGINIA GIPE,
Secretary-Treasurer

MICHIGAN SEWAGE WORKS ASSOCIATION

22nd Annual Conference

Jackson, Michigan, May 14–16, 1947

The 22nd Annual Conference of the Michigan Sewage Works Association was held at Jackson on May 14–16, 1947. A total of 178 members and guests were registered. The short course school for operators, held in previous years in conjunction with the conference, was deferred this year until June 2. The school will be expanded from the usual two days to a six weeks' period of instruction and laboratory practice comprised of six related courses, each of one week duration.

The conference was opened with an address of welcome delivered by Clarence H. Elliott, city manager of Jackson. President R. A. Greene, acting superintendent of the Jackson sewage treatment plant, presided at the technical sessions which were of particular interest to sewage plant personnel. The May 14 session began with a panel discussion led by C. T. Mudgett, superintendent of sewage treatment at Muskegon, which covered various aspects of plant maintenance. R. D. Thayer, president of the R. D. Thayer Company of Detroit, talked on moisture control in concrete masonry maintenance; Michael A. Groen, superintendent of sewage treatment at Dearborn, discussed maintenance of equipment; and N. G. Damoose, director of public service at Battle Creek, explained an effective system of records and reports for use in sewage treatment plants. Other papers presented in the opening session were: "Carbide Lime Slurry for Sludge Conditioning" by Harold M. Leonhard, chemist of the Wayne County sewage disposal system, and "Chlorination of Sewage" by O. E. McGuire, sanitary engineer of the Michigan Department of Health.

The May 15 session opened with a round table discussion on the "Operation and Control of Sludge Digestion Facilities" led by C. P. Witcher, superintendent of sewage treatment at Ann Arbor. Viewpoints on chemical and biological activities, sludge digestion, capacity, effect of temperature and stage digestion were presented, prompting an active debate on these and related matters. Two topics presented of interest to consulting engineers and municipal officials, as indicated by their comments, were: "Engineering Planning of Sewage Collection and Treatment Works" presented by Earnest Boyce, professor of municipal and sanitary engineering at the University of Michigan, and discussed by Walter Drury, consulting engineer with Shoecraft, Drury & McNamee, and "The Financing of Sewer Systems and Sewage Treatment Plants" by Leonard Howell, city manager of Port Huron, and discussed by George Liddle, city manager of Muskegon. "The Operation and Maintenance of a Small Activated Sludge Plant" was presented by Leonard Hillis, superintendent of sewage treatment at the Caro State Hospital in Caro, Michigan, and discussed by R. A. Greene.

The program for the third day was devoted entirely to subjects dealing with industrial waste treatment and disposal. J. E. Cooper, chief. Water and Wastes Laboratory, Ford Motor Company at Detroit, was program chairman for the day. The following papers were presented:

"Introduction to the Industrial Waste Problem" by E. F. Eldridge, Research Associate of the Engineering Experiment Station, Michigan State College at East Lansing.

"The State's Attitude" by Milton P. Adams, executive secretary and

engineer of the Michigan Stream Control Commission at Lansing.

"Municipal Regulations for Control of Sewer Usage by Industry" by Clyde L. Palmer, senior associate engineer in the sanitary division of the city engineering department in Detroit, with discussion by L. A. Danse, supervisor of material and processes of the General Motors Corporation, Detroit.

"An Industry Initiates a Waste Disposal Program" by J. E. Cooper, chief, Water and Wastes Laboratory of the Ford Motor Company.

"Determination of the Type and Degree of Treatment Required for an Industrial Waste" by Philip F. Morgan, engineer in charge of the Kalamazoo Project, National Council for Stream Improvement of the Pulp, Paper and Paperboard Industries.

"Treatment of Cyanide Wastes by Chlorination" by John G. Dobson, Wallace and Tiernan Company, Niagara Falls, N. Y., with discussion by Dr. A. S. Hazzard, director of the Institute for Fisheries Research, Department of Conservation in Ann Arbor.

"Reducing Pollution Caused by Milk Waste" by A. J. Steffen, sanitary engineer of the Research and Technical Department of Wilson and Company, Chicago, Ill.

"Use of Lagoons for the Disposal of Cannery Wastes" by T. F. Wisniewski, senior assistant sanitary engineer of the Wisconsin Department of Health.

The annual smoker and dinner was attended by 88 members and guests. John M. Hepler, director of the Bureau of Engineering of the Michigan Department of Health, gave a colorful talk, illustrated with colored slides, on observations in Puerto Rico, where he has lectured the past two years at the School of Tropical Medicine. Two motion pictures were presented by the Michigan Department of Conservation.

Merrill Graham, executive secretary of the Greater Jackson Association, gave an interesting and inspiring talk on the resources of Michigan at the annual association banquet. The Water and Sewage Works Manufacturers' Association provided highly successful club room entertainment during the conference.

At the business meeting the following officers were elected for the ensuing year:

President: T. J. Powers, Midland
Vice-President: A. T. Kunze, Detroit
Secretary-Treasurer: D. M. Pierce, Lansing
Directors: M. A. Groen, Dearborn
Earnest Boyce, Ann Arbor
R. A. Greene, Jackson
FSWA Director: W. F. Shephard

D. M. PIERCE,
Secretary-Treasurer

MONTANA SEWAGE WORKS ASSOCIATION

3rd Annual Meeting

Havre, Montana, April 23–24, 1947

The Third Annual Meeting of the Montana Sewage Works Association was held in Havre on April 23–24, 1947.

Kenneth Chrysler, Chairman of the Montana Sewage Works Association, presided at the opening session. Director J. M. Schmit and Secretary-Treasurer H. B. Foote presented their annual reports, following which there was a showing of the motion picture, "Clean Waters," by courtesy of the General Electric Company.

The technical session opened with a discussion on "The Design and Construction of Sanitary Sewer Systems,"

led by Kurt Wiel of Miles City. F. F. Palmer, Forsyth, discussed grades and sewer sizes; C. W. Eyer, Glendive, talked on minimum coverage; H. B. Foote, Helena, discussed location and inspection of sewers; J. M. Schmit, Lewistown, reported on multiple uses of sewers; Kenneth Chrysler, Billings, covered the subject of jointing materials; Ed Henen, Great Falls, discussed manholes, lampholes, and flush tanks; W. Swearingen, Missoula, talked on the financing of sewer construction; and John W. Hall, Fort Shaw, concluded with a general discussion and summary.

W. R. LaDue gave an address entitled "The AWWA Policy with Reference to Stream Pollution Legislation." W. M. Cobleigh led a discussion devoted to sewage works planning for various Montana towns and cities.

Sewage treatment plant operation reports were given by Joseph Wright of Lewistown and Keith Winebrenner of Kalispell.

Chairman Kenneth Chrysler presided at the business session. Officers elected to serve during 1947–48 were:

Chairman: Keith Winebrenner, Kalispell
Vice-Chairman: F. F. Palmer, Forsyth
Secretary-Treasurer: H. B. Foote, Helena
FSWA Director: Kenneth Chrysler, Billings
Trustees: F. E. Brandis, Chinook and Joseph Wright, Lewistown

The incoming chairman was instructed to appoint a committee of five to work with the State Board of Health during the coming year in an attempt to establish standard practices of design, construction and management of sanitary sewer systems in Montana.

W. M. Cobleigh, Dean Emeritus, School of Engineering of State College at Bozeman, was nominated to receive the Federation's Kenneth Allen Award, in recognition of his leadership in the organization of the Montana Sewage Works Association, and his many years of professional activity in the state in connection with sewage and industrial wastes disposal.

H. B. Foote,
Secretary-Treasurer

NEW YORK STATE SEWAGE WORKS ASSOCIATION
NEW ENGLAND SEWAGE WORKS ASSOCIATION

3rd Joint Meeting

Albany, New York, May 26–27, 1947

The third joint meeting of the New York State Sewage Works Association and the New England Sewage Works Association was held at the Hotel Ten Eyck in Albany on May 26–27, 1947. Registration totaled 303 members and guests. From the standpoint of both the technical sessions and the entertainment program the meeting achieved notable success.

The technical program included the following papers and discussions:

"U. S. Army in the Far East" by John D. McDonald, sewage treatment plant engineer at Springfield, Mass.

"Sludge Drying with Roto-Louvre Dryers" by Morton Goldstein, eastern manager of the Dryer Division, Link Belt Company, Philadelphia.

"Experiences in the Thickening and Drying of Sludge" by Thomas R. Komline president of Komline-Sanderson Engineering Corporation, Ridgewood, N. J.

"Current Developments in Sewage and Industrial Wastes Treatment" by Francis S. Friel, FSWA President.

"A Problem of Disposal of Wastes from Plating Metal Parts Used in the Manufacture of Aircraft Engines" by

Stuart E. Coburn, Metcalf and Eddy, Engineers, Boston, Mass.

"Federal and State Legislation for Stream Pollution Control" by Morris Cohn, sanitary engineer of Schenectady, N. Y.

A symposium on "Maintenance of Digestion Tanks" was led by Joseph Doman, sanitary engineer of Greenwich, Conn.

A second symposium on "Sewer Maintenance Problems" was led by Harry Fitts, engineer of the sewer maintenance bureau, Borough of Queens, N. Y.

"Use of Transite Pipe" by A. J. Maahs, Transite Pipe Department, Johns-Manville, New York.

"Orangeburg—The Root-proof Pipe" by Robert D. Ellis, research engineer of the Fibre Conduit Company, Orangeburg, N. Y.

"Effects of Industrial Wastes" by Richard Hazen, consulting engineer of Malcolm Pirnie Engineers, New York.

"Technical Papers—Their Preparation and Presentation" by George E. Symons, associate editor of *Water and Sewage Works*, New York.

"Operator Salaries" by Thomas R. Camp, of Camp, Dresser and McKee, Consulting Engineers, Boston, Mass.

At the luncheon meeting on May 26, the NYSSWA Rating Award was presented by William Denise, Chairman, to John W. Eagleson, operator of the Great Neck Sewer District, for the best report on plant operation. William Edwards, operator of the Gowanda State Hospital sewage treatment plant, received the Rating Award for his report on the Gowanda Hospital plant.

FSWA President Francis S. Friel presented to John W. McDonald the Federation's George Bradley Gascoigne Award for the year 1945. Presentation of this award had been delayed because of Mr. McDonald's absence in military service. Mr. Friel also read a citation announcing the nominations of Wellington Donaldson of the NYSSWA and of Stuart E. Coburn of the NESWA for the Federation's 1947 Kenneth Allen Award.

At the dinner meeting Secretary A. F. Dappert of the NYSSWA presented to previous winners the awards which were earned but which could not be presented during the war years because of the inability to procure cups and plaques. These included Rating Awards to William Edwards, Gowanda State Hospital, and Harry Monsell, Greenport; Kenneth Allen Memorial plaques to Thomas M. Riddick, H. O. Johnson, Lloyd B. Setter, Gail P. Edwards, Harry W. Gehm, Rolf Eliassen and H. B. Schulhoff.

Entertainment features included a ladies' luncheon followed by a bridge party and tour of the State Museum, a club room hour by courtesy of the Water and Sewage Works Manufacturers Association, and a show, "House of Magic," presented in Chancellor's Hall by the General Electric Company.

A. F. DAPPERT,
Secretary-Treasurer

PACIFIC NORTHWEST SEWAGE WORKS ASSOCIATION

1947 Annual Meeting

Victoria, B. C., Canada, May 14, 1947

The 1947 Annual Meeting of the Pacific Northwest Sewage Works Association was held at the Empress Hotel in Victoria, Canada, on May 14, 1947. Registration totaled 120 members and guests.

The conference was formally opened with an address of welcome by Percy E. George, Mayor of Victoria. C. M. Howard presided at the technical session which followed.

First on the program was a forum

on "The Status of Water Pollution Control in the Pacific Northwest." H. C. Clare, director of the Division of Public Health Engineering of the State Department of Health in Boise, Idaho, discussed water pollution control in Idaho. He stressed the fact that legislative control over pollution of surface or ground water that may be caused by domestic sewage wastes is inadequate. Legislation and centralized control are imperative. Curtiss M. Everts, Jr., state sanitary engineer of the Oregon State Board of Health, listed the factors involved in determining the required degree of sewage and waste treatment. He discussed briefly those fundamental factors which must be taken into consideration in the development of a reasonable program of stream purification for Oregon. Hamilton R. Johnson, chief engineer of the State Pollution Control Commission at Olympia, Wash., covered the status of pollution control in that state, emphasizing the development of a program for the utilization of pulp and paper mill wastes. He pointed out how industry is making considerable progress in this direction in Washington. Emil C. Jensen, chief of the Division of Public Health Engineering at Seattle, Wash., explained the status of sewage pollution control in the state of Washington. He told how the state has had the greatest year of sewage works planning ever experienced, but construction has not kept pace with the rate of planning.

The morning program continued with a panel discussion on "Sewer Systems." Harry Sisler, consulting engineer at Kirkland, Wash., discussed hydraulic design and the main factors involved in the general design of sewer systems, emphasizing the importance of complete topographical information and of the engineer's general knowledge of sewer systems. Sewer design was discussed by George R. Hammond, General Engineering Company, Seattle, Wash. Mr. Hammond illustrated the effects of velocity, shape and type of pipe and loading, and described the probable loading conditions on sewer pipe with emphasis on the need of control during construction. These papers were discussed by Loren Thompson of Portland, Ore., and Fred C. Steward of Vancouver, B. C.

William P. McNamara, city engineer of Seattle, Wash., gave an interesting paper on sewer pipe jointing, describing the development and use of a pipe jointing machine that has proved very successful.

At the noon luncheon, W. H. Wisely, executive secretary of the Federation of Sewage Works Associations, spoke on "Public Relations at the Local Level," stressing the importance of public relations from the sewage plant operator's standpoint and using illustrations from his own actual experience as an operator.

At the afternoon session, Prof. R. G. Tyler of the University of Washington at Seattle presided.

"Sewer System of the City of Vancouver, B. C." was presented by J. C. Oliver, assistant engineer of the city of Vancouver. Mr. Oliver described the problems that have arisen with the increased population in Vancouver and stressed the need for good planning in these days of rapid growth in the Pacific Northwest.

Carl E. Green, consulting engineer, Portland, Ore., presented a paper "Effect of Industrial Wastes on the Design, Construction and Operation of Sewage Works." Mr. Green emphasized the need for cooperation between industry, municipality and state in arriving at solutions to waste disposal problems. Without complete cooperation, he pointed out, it is seldom possible to develop an adequate system to handle industrial wastes, illustrating his point by reciting the history of a project at Puyallup, Wash.

"Factors Involved in Determining the Degree of Treatment Required" was thoroughly covered by Curtiss M.

Everts and Kenneth H. Spies of the Division of Sanitary Engineering, Oregon State Board of Health. Fundamental factors which must be taken into consideration in the development of a reasonable program of stream sanitation were brought out. The authors stated that the damages caused by the great amount of pollution to domestic water supplies, fisheries, recreation, industry, navigation, agriculture and property values exceed $100,000,000 annually.

At the Annual Dinner, Dr. Adolph Weinzirl, Professor of Public Health at the University of Oregon Medical School, related in interesting fashion the history and progress in medicine and sanitation since ancient times, giving due credit to the work of the regional units of the Federation of Sewage Works Associations in the elimination of stream pollution.

Robert E. Leaver, member of the special investigation committee on ozone treatment of sewage, reported on the West Kelso plant built by "Amozone of Oregon." He stated that this plant has not ben abandoned as has been rumored. There seems to be more confidence than ever on the part of the builders that the plant will be successful. Extensive redesign of the plant has taken place and new features are now being installed. Mr. Leaver stated also that at this time there seems to be no reason whatever to modify the conclusions or recommendations of the committee as they were made last year and approved by the association, but it is apparent that definite conclusions can be reached about the success or failure of the plant before the end of this summer.

At the business meeting the following officers were elected to serve during the year of 1947–48:

President: H. C. Clare, Boise, Idaho
First Vice-President: K. H. Spies, Portland, Ore.
Second Vice-President: Emil C. Jensen, Seattle, Wash.
Secretary-Treasurer: Wm. P. Hughes, Lewiston, Idaho
FSWA Director: C. M. Howard, Seattle, Wash.

WM. P. HUGHES,
Secretary-Treasurer

WEST VIRGINIA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

Organization Meeting

Charleston, W. Va., June 20, 1947

The West Virginia Sewage and Industrial Wastes Association, organized at Charleston, W. Va., on June 20, 1947, became the 31st unit of the Federation when the Board of Control met at San Francisco in July. The new association enrolled a charter membership of 59 from the group of 66 engineers and chemists who registered at the organization meeting. About half of the charter members are representatives of industry.

Groundwork toward creation of the new association was carried on under the leadership of J. B. Harrington, state sanitary engineer of West Virginia, assisted by K. S. Watson, chemical engineer of the State Water Commission. These preliminary functions included drafting of a tentative constitution and by-laws, arrangements for the Charleston meeting and issuance of invitations to interested persons in the state.

W. D. Moses, chemical engineer, E. I. DuPont de Nemours and Co., served

as temporary chairman in conducting the organization meeting. The session was opened by H. K. Gidley and R. G. McCall, sanitary engineers in the state department of health, who discussed the stream pollution problem in West Virginia and reported on the status of sewage and industrial waste treatment in the state. An address "The Aims and Accomplishments of the Federation of Sewage Works Associations" was then presented by Francis S. Friel, President of the international organization, in which Mr. Friel described the varied activities of the Federation and cited the progress being made in achieving its objectives. The formal program was concluded by W. H. Wisely, FSWA Executive Secretary and Editor, who spoke on "An Activity Program for a Regional Sewage Works Association." Emphasis was placed in these remarks on the value of special technical committees, a periodical association newsletter, public relations functions, training and licensing of operators, etc., all as commendable activities.

The tentative constitution and by-laws was reviewed in detail and, after some modification, was formally adopted. Upon recommendation by a special nominating committee the following officers were elected: President —Kyle L. Bruce, Bluefield; First Vice-President—P. D. Simmons, Weirton; Second Vice-President—J. E. Sexton, Charleston; Secretary-Treasurer—R. G. McCall, Charleston; FSWA Director—K. S. Watson, Charleston.

The Executive Committee was authorized to select the place and date of the first annual meeting of the association, and to act on an invitation extended by the West Virginia Section of AWWA for the sewage works group to meet at Bluefield on October 1, 1947, the day preceding the AWWA section annual meeting.

The meeting was concluded by showing of the moving picture "Clean Waters."

MEMBER ASSOCIATION MEETINGS

Association	*Place*	*Time*
West Virginia Sewage and Industrial Wastes Assn.	West Virginia Hotel, Bluefield, W. Va.	Oct. 1–2
Ohio Conference on Sewage Treatment	Deshler-Wallick Hotel, Columbus, Ohio	Oct. 2–3
Canadian Institute on Sewage and Sanitation	General Brock Hotel, Niagara Falls, Ont., Canada	Oct. 6–8
Iowa Sewage Works Assn.	Hotel Montrose, Cedar Rapids, Iowa	Oct. 9–10
Arizona Sewage Works Assn.	El Tovar Hotel, Grand Canyon, Ariz.	Oct. 9–11
Virginia Industrial Wastes and Sewage Works Association	Nansemond Hotel, Ocean View, Va.	Oct. 16–17
Missouri Water and Sewage Conf.	Governor Hotel, Jefferson City, Mo.	Oct. 27–28
North Carolina Sewage Works Assn.	Sedgefield Inn, Greensboro, N. C.	Nov. 10–12

Federation Affairs

THE TWENTIETH ANNUAL MEETING

Favored by exceptionally fine weather and exceptional hospitality, both typical of the reputation of the state of California, the 20th Annual Meeting of the Federation held at San Francisco on July 21–24, 1947 was a gratifying success. The meeting was held concurrently with the 67th Annual Conference of the American Water Works Association and in conjunction with the 19th Annual Meeting of the California Sewage Works Association, and brought a notable array of firsts to the 964 registrants—the first annual meeting west of Chicago; the first annual meeting held concurrently with an organization other than a member association; the first annual meeting having joint technical sessions with the national water works group; the first annual meeting to be favored by more than a hundred exhibitors. In a real and satisfying way the 20th Annual Meeting brought the Federation to the West Coast and, conversely, brought to the West Coast a more intimate understanding of the Federation.

The total registration of 964 considerably exceeded the previous record attendance of 812 at Toronto in 1946. It is significant, however, that the 712 men registrants included 401 manufacturers' representatives who were required to register for both the FSWA and AWWA meetings. The 964 figure also includes 252 ladies' registrations.

A geographical breakdown of the 409 registrations handled directly at the Federation desk reveals that 242 were registered from California, 80 from states west of the Mississippi other than California, 83 from states east of the Mississippi, and 4 foreign.

The spacious Civic Auditorium was of ample size to permit the simultaneous sessions of both groups, without interference of any kind. Located between the two convention halls, the huge Arena afforded an ideal setting for the 110 exhibiting members of the Water and Sewage Works Manufacturers Association. Truly the greatest display of water and sewage works equipment ever assembled, the colorful and interesting exhibits overflowed the main Arena area and nearly filled the adjacent corridors. Fully two-thirds of the exhibits represented equipment or services of interest to sewage works technicians. There was no lack of opportunity to examine the latest developments in equipment and to discuss associated problems with informed manufacturers' representatives.

Acting as host to the Federation, San Francisco members of the California Sewage Works Association did an exceptional job in handling the preparations for the meeting. Special credit is due the Joint Local Arrangements Committee, in which the Federation was represented by Blair I. Burnson as co-chairman, with C. C. Kennedy, George White, Harold L. May, Gilbert T. Bowman and J. H. Peterson, which committee so effectively paved the way for the smooth and efficient operation of the conference. The work of the Joint Housing Committee also deserves special praise. Under the direction of Nelson Eckart this committee did a remarkable job in handling hotel reservations and in placement of members in the fifteen hotels. Very few reservations went astray and, as far as could be determined, rooms were located for all with courtesy and dispatch.

Preconvention registration opened Monday, July 21, and many took advantage of this opportunity to register early. The 20th Annual Meeting was convened at 9:00 A.M. on Tuesday, July 22, by President Francis S. Friel. In his opening remarks, President Friel briefly reviewed Federation progress during his tenure of office and reviewed the problems and opportunities facing the Federation in the immediate future. Following presentation of a short summary report by the Executive Secretary, President Friel introduced President-elect George S. Russell and presented S. C. Martin, who recently joined the Federation headquarters staff as executive assistant.

Engineering Library

Technical Programs

Highlighted by two joint sessions with the American Water Works Association, the technical program developed by the Publications Committee was outstanding. The program was generally slanted toward the problems of the western states, although there was no lack of papers on subjects of broad interest. Attendance of the technical sessions was particularly good, and many commendatory remarks were heard concerning the over-all excellence of the program.

The abbreviated Tuesday morning session offered papers on the sewage collection and treatment problem at San Francisco, by Clyde C. Kennedy, and on the project at Portland, Ore., which was delivered by H. Loren Thompson. Ralph G. Wadsworth and A. M. Rawn were the respective discussers.

Tuesday afternoon was devoted to a joint session with AWWA in the form of a symposium on ground water pollution. Papers on basic legal concepts (A. P. Black), ground water production works (Malcolm Pirnie and R. W. Sawyer), ground water pollution control legislation (B. E. Doll) and pollution limit standards (R. F. Goudey) were included. The latter two papers were discussed by Frank Stead. The session was held in Larkin Hall with AWWA as host and with AWWA President Wendell R. LaDue presiding. It was one of the highlights of the meeting.

Vice-President George S. Russell presided at the Wednesday morning session, which opened with a paper describing natural purification characteristics of a shallow turbulent stream, presented by F. W. Kittrell and discussed by George E. Symons. The remainder of the period was given to three industrial waste topics: a paper on the influence of waste disposal practices on industrial operating costs by William J. O'Connell and discussed by Herbert C. Davis; a moving picture and review of cannery waste treatment and disposal methods by L. F. Warrick and discussed by C. W. Klassen; and a report of the activities of the Special Committee on Industrial Wastes of the California Sewage Works Association by W. T. Knowlton, chairman of the committee. High interest and good attendance were noted in this session.

The technical highlight of the entire meeting was probably the Wednesday afternoon joint session at which AWWA was the guest of the Federation in Polk Hall. The theme of the symposium was "Reclamation of Sewage Effluents," a topic on which the limited literature heretofore no doubt accounted largely for the size and response of the audience. With President Friel presiding, an informative series of papers was presented including a review of past practice in the industrial usage of sewage effluents, by N. T. Veatch and discussed by Earnest Boyce; a detailed report by Abel Wolman on the reclamation of Baltimore sewage works effluent for industrial purposes, discussed by Ray F. Goudey; an authoritative study of agricultural uses of treated sewage by L. V. Wilcox, discussed by Dario Travaini; and a comprehensive analysis by S. T. Powell of pollution limits for water used in industry.

Thursday morning featured the annual Operators' Forum, arranged and conducted by Frederick G. Nelson for the California Sewage Works Association. The hydrogen sulfide control problem at Long Beach, Calif., was reviewed in a paper presented by D. R. Kennedy and discussed by Ewald Lemcke. The always pertinent topic of sewer maintenance was covered by Don C. Davis and A. Segel. Of considerable interest was the paper by Reuben F. Brown on salaries schedules for sewage works operation personnel, discussed by Morris M. Cohn. A popular part of all Federation meetings, the Forum is usually notable for the open discussion that is encouraged. The size and arrangement of Polk Hall, however, was not conducive to the informal atmosphere that is desirable for a program of this kind, and audience participation was somewhat disappointing.

The closing technical session, presided over by Charles Gilman Hyde, comprised an outstanding group of three papers on the B.O.D. determination. Professor Harold B. Gotaas discussed the influence of temperature on the rate and degree of ultimate demand; Prof. W. F. Langelier and David H. Caldwell described research on the monometric measurement of B.O.D.; and Prof. R. G. Tyler reported experience in the application of the B.O.D. determination to the analysis of sulfite waste liquors.

Entertainment Events

The highly successful social program was opened with a reception and dance on Monday evening, a joint AWWA and FSWA function. An estimated 700 persons took advantage of this occasion to be greeted by the national officers and to enjoy the entertainment and dancing in the Colonial Ball Room of the St. Francis Hotel. A troupe of Hawaiian entertainers featured native music and dances, catching the fancy of the audience in spite of a largely unsuccessful attempt to educate a group of officials in the intricacies of the dance for which Hawaii is most famous.

The Gala Entertainment on Tuesday evening was also a joint venture. The program was presented in the Exhibit Arena of the Civic Auditorium, with more than 1,500 persons in attendance. Audience response to the 2½-hour program of select vaudeville entertainment bespoke the successfulness of the event.

On Wednesday evening was held the annual Federation Dinner and Dance, in the Colonial Room of the St. Francis. Despite the disappointing attendance of only 254, an excellent dinner and smoothly conducted program under President Friel's direction made the event a highlight. The feature of the occasion was the announcement and presentation by President Friel of the annual Federation awards. Group singing and a series of beautifully done spirituals by a young baritone singer rounded out the dinner hour, after which there was dancing.

Ladies' Entertainment

More than 500 ladies enjoyed the delightful program of entertainment provided by the Joint Ladies' Entertainment Committee, which functioned so well under the direction of Mrs. Nelson Eckart. The Tuesday tea and Chinese fashion show pleased all of the ladies, the stunning collection of Chinese gowns furnished by the renowned Gumps' of San Francisco and Honolulu having particular appeal. An all-inclusive sightseeing tour of San Francisco's points of interest occupied most of Wednesday afternoon. The Thursday afternoon luncheon-bridge party, in the beautiful Tonga Room of the exclusive Fairmont Hotel high atop Nob Hill, concluded the series of special events provided for the ladies.

Convention Attendance Award

As usual, the Central States Sewage Works Association won the annual Convention Attendance Award, its 24 registrants having aggregated 41,000 miles of travel in attending the meeting. This latest triumph retires the second award trophy to the permanent possession of the CSSWA.

California Business Luncheon

The California Sewage Works Association held its annual business luncheon at the Whitcomb Hotel on Thursday, with 90 members and guests present. Federation President Friel and Executive Secretary Wisely spoke briefly to the group. Officers elected by the Association for 1947 were: *President*—Harold L. May, Palo Alto; *1st Vice-President*—Ray L. Derby, Los Angeles; *2nd Vice-President*—R. R. Ribal, Oakland; *Secretary-Treasurer*—L. H. Cook, Menlo Park.

BOARD OF CONTROL MEETS AT SAN FRANCISCO ON JULY 21 AND 24, 1947

Several items of important business were given attention by the 1947 FSWA Board of Control in special sessions held before and following the San Francisco convention. These sessions, held on July 21 and July 24 at the St. Francis Hotel, would ordinarily have constituted the annual meeting of the Board. A provision in the By-laws, however, specifies that the annual meeting shall be held in October, and action was taken to schedule the 1947 annual business meeting of the Board for Philadelphia on October 10.

All business normally considered at the annual meeting of the Board was considered at the July sessions, actions on all matters pertinent to future operations being in the form of recommendations to the 1948 Board. Some of the more impor-

tant matters given attention are summarized briefly in the following paragraphs.

Secretary's Report

The report of the Executive Secretary, covering all details of management and administration of the Federation for the 9-month period ended on June 30, 1947, was approved by the Board. The affiliation of new Member Associations in Kentucky-Tennessee, Virginia, Puerto Rico and West Virginia was reported to have increased the number of Federation units to 32 associations, having an aggregate membership on June 30 of 3,998 Active and Corporate members. Reference was also made to current organizational activity in Alabama, Louisiana and Brazil.

Financial progress of the Federation was exemplified by a tabulation of net worth values in recent years. An increase in net worth from $3,075.78 on December 31, 1940, to $35,058.15 on December 31, 1946, was shown.

Standard Methods Agreement Authorized

One of the most important matters considered by the Board was a proposed agreement providing for the publication of future editions of the book *Standard Methods for the Examination of Water and Sewage* jointly by APHA, AWWA and the Federation. The agreement was approved, culminating several years of effort toward the recognition of the Federation as a participating publisher of the book.

Research Project Initiated

Chairman W. D. Hatfield of the Committee on Standard Methods of Sewage and Industrial Wastes reported to the Board that the Federation had been allocated a Federal grant of $33,830 to finance a comprehensive research project on analytical methods. The grant was made by the U. S. Public Health Service through the National Institute of Health. Various parts of the project will be undertaken in the established laboratories at Rutgers University, the Wisconsin State Laboratory of Hygiene, Mellon Institute, the Illinois State Water Survey, the New York State Division of Laboratories and Research, and a sixth yet to be selected.

The Board considered the mechanics of the project, and adopted a resolution placing its administration and management under the Committee on Standard Methods of Sewage and Industrial Wastes. The funds, however, will be disbursed through the headquarters office.

Reorganization Proposal Dropped

The General Policy Committee, acting on a directive from the Board sessions at Toronto, reported on its consideration of a proposal that the Federation be reorganized into a national association with regional sections. Such reorganization was not recommended by the Committee at this time and it was urged that future action along these lines should be taken only if a canvass of the membership indicates a demand for it to exist.

President Friel polled the members of the Board for personal opinions in the matter, and almost unanimous opposition to any reorganization was expressed.

Operators' Salaries to be Studied

A directive was extended to the existing Committee on Operators' Qualifications to expand its functions to include the study of salary schedules in use for sewage works operation personnel, and to develop recommendations relating to desirable levels of compensation for such personnel. The committee will be titled henceforth as the Committee on Operators' Salaries and Qualifications.

Industrial Wastes Forum Authorized

Upon recommendation of the Committee on Industrial Wastes, the Board acted to authorize inclusion in the program of future annual meetings a special Industrial Wastes Forum to be devoted to open discussion of industrial wastes problems, and to be reported for subsequent publication in the JOURNAL. Other plans of the committee pertaining to promotion of membership and of services to industrial wastes technicians, were approved.

1947 Awards

The Board acted to approve the following 1947 Federation awards:

The *Harrison Prescott Eddy Medal,* for outstanding research, to Richard Pomeroy

and Fred Drexel Bowlus for their paper "Progress Report on Sulfide Control Research" (THIS JOURNAL, 18, 4, 597; July, 1946).

The *George Bradley Gascoigne Medal,* for an outstanding contribution in sewage works operation, to Leon S. Kraus, for his paper "Digested Sludge—An Aid to the Activated Sludge Process" (THIS JOURNAL, 18, 6, 1099; November, 1946).

The *Charles Alvin Emerson Medal,* for extraordinary service to the Federation, to Langdon Pearse "in recognition of his outstanding contributions over many years to the art of sewage treatment and to the practical application of sanitary science to important engineering works; and in appreciation of his service and loyalty to the Federation as exemplified by his editorship of *Modern Sewage Disposal,* the Tenth Anniversary Book of the Federation, and by his services in the production of Manual of Sewage Works Practice No. 2."

The *Kenneth Allen Awards,* for outstanding service to Member Associations of the Federation, to William T. Knowlton (California), Floyd W. Pinney (Dakota), Gilbert R. Frith (Georgia), Clarence Edward Keefer (Maryland-Delaware), Stuart E. Coburn (New England), Wellington Donaldson (New York), Henry J. Darcey (Oklahoma), Carroll H. Coberly (Rocky Mountain), William Storrie (Canadian Institute) and William Merriam Cobleigh (Montana).

A decision was reached that the Eddy, Gascoigne and Emerson medals will be produced in the permanent form of specially designed medallions to be mounted with appropriately engraved nameplates on a wood display plaque. When available, these plaques are to be granted to all past recipients of the above awards, as well as to future recipients.

Legislation Opposed

A resolution was adopted in opposition to the passage by the 80th Congress of H.R. 3215, a measure which proposes to revise the organization of the medical services of the Army and Navy. The legislation was deemed undesirable because it subordinated non-medical technical personnel, made possible the misapplication of such personnel and would result in loss of professional identity.

Quarter-Century Club Grows

The admission of three new members to the Quarter-Century Operators Club was reported to the Board by Frank Woodbury Jones, chairman of the club's administrative committee. The new members are E. Sherman Chase of Boston, Earl Devendorf of Albany, N. Y., and Arnold H. Goodman of Chicago. A total of 30 members are now included in the club roster.

The Executive Secretary was instructed to develop a suitable membership certificate for distribution to current and new members of the club.

New Associate Members

Five new Associate Members were admitted to the Federation by Board action, as follows: Walker Process Equipment, Inc., the Eastern Sewage Disposal Co.; the Sidu Company, the Albert Pipe Supply Co., and the Geo. H. Werfelman Co. These admissions increase the total membership in this classification to 75.

Future Meeting Places Confirmed

The Board confirmed the designation by the Meeting Place Committee of Detroit and Boston, respectively, as the sites of the 1948 and 1949 annual conventions of the Federation. Tentative approval was given the recommendation of Denver as the 1950 meeting place, subject to a survey of hotel facilities there.

Invitations for meetings subsequent to 1950 to be held at New York City, Miami, Fla., and Washington, D. C., were received.

Membership Contests Continued

Noting the high level of interest in the membership contests which have been sponsored during the past several years, the Board authorized their continuance for the year 1947–48. Two prizes of $100 each will be offered, one to the Member Association recording the greatest numerical increase and the other to the association showing the greatest percentage increase in membership for the year ending in September 30, 1948.

1947–48 Officers

In a session held on July 21, 1947, the Election Committee elected the following officers for the periods indicated: *Presi-*

dent—George S. Russell of St. Louis, Mo., *Vice-President*—V. M. Ehlers of Austin, Texas, *Treasurer*—W. W. DeBerard of Chicago (all for the year of October, 1947 to October, 1948), and *Director-at-Large*—Don E. Bloodgood of Lafayette, Ind. (for a three-year period beginning in October, 1947).

For two-year appointments beginning January 1, 1948 the Board recommended W. H. Wisely for the combined office of Executive Secretary-Editor and Dr. F. W. Mohlman for the position of Advisory Editor. These appointments are subject to confirmation by the 1948 Board on October 10, 1947.

Reviews and Abstracts

Edited by

H. GLADYS SWOPE *

Allegheny County Sanitary Authority,
4501 Center Avenue, Pittsburgh 13, Pa.

West Middlesex Main Drainage—Ten Years' Operation. BY C. B. TOWNEND. *Journal Inst. Civil Engineers,* **27**, 351–414 (February, 1947).

This paper on operation supplements the paper of D. M. Watson on the design and construction of the West Middlesex main drainage (*J. Inst. C. E.,* **5**, 433, April, 1937).

The project serves 15 local authorities, covering 162.36 sq. mi. with a population exceeding 1,200,000. The plant has been in full operation since May, 1936. All the 28 works serving the individual districts have been closed down.

The present minimum monthly average flow is about 60 (Imp.) m.g.d. or 72 (U.S.) m.g.d. or 60 g.p.c.p.d. U.S. The local sewers are on a separate or partially separate basis but the total rate has seldom exceeded 288 (Imp.) g.p.c.p.d. The sewer capacity is 600 (Imp.) m.g.d. The highest rate of flow was 455 (Imp.) m.g.d. Local sewers receive about 7 per cent of the runoff. Most of the area served is within 2 hr. concentration period.

Overflows are rare. 97 per cent of the flow has received full treatment; 3 per cent sedimentation for 2 hours.

The larger sewers have a vitrified brick lining and show no wear. Infiltration into the main sewers does not exist. Perforated manhole covers have been unsatisfactory on 75 per cent of the system. Inverted siphons have been flushed weekly. There are about 130 connections to local sewers, with adequate water-cushions and reduction of velocity. The twelve 6-ft. effluent outfalls pass under the Thames River and terminate vertically upward with a minimum velocity of 0.25 f.p.s. They are flushed out twice a year, one at a time. There are practically no deposits in the sewers, with a minimum velocity of 2 f.p.s. The sewer maintenance on 70 mi. in 1938–1939 cost £5,230 (about $20,920). This is done with specially organized gangs, operating with motor trucks.

The Mogden plant is the largest complete plant outside the U. S. The site includes 100 acres, of which 45 acres are now used by the works. The general basis of design (cf. Watson supra) proved conservative. The plant has handled 1,200,000 population and additional trade waste.

The sewage contains a considerable amount of organic industrial wastes from breweries, yeast-works and other food products. For the last 4 yr. the 5-day B.O.D. per capita per day has averaged 0.16 lb. with a maximum month of 0.19 lb.

The screenings are macerated. The grit-chambers operate at 1 f.p.s., producing about 5 cu. yd. per day of sandy material (97.5 per cent fixed).

Sedimentation in dry weather (about 6 hr.) reduces the suspended solids about 80 per cent—from 300–350 p.p.m. in the raw sewage to 60 or 70 p.p.m. in the secondary tank effluent. For the 10 yr. period, the average reduction was 71 per cent, from 238 to 69 p.p.m. of suspended solids; and of 5 day B.O.D. 44 per cent, from 307 to 172 p.p.m. The crude sludge contains 75 to 80 per cent organic matter. At the maximum rate of flow (120 Imp. gal. p.c. p.d.) the sedimentation period is 2½ hr. (primary 50 min., secondary 100 min.). The settling tanks also receive the return sludge which adds about 120 p.p.m. suspended solids to the sewage flow.

* It will be appreciated if Miss Swope is furnished all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in THIS JOURNAL. Publications of public health departments, stream pollution control agencies, research organizations and educational institutions are particularly desired.

In 1936, for 10 months following June, the effluent of the activated sludge plant contained 6 p.p.m. 5 day B.O.D. and 21.9 p.p.m. nitrate, with 1.24 cu. ft. air per Imp. gal. (1.03 cu. ft. per U. S. gal.) or 788 cu. ft. per lb. of B.O.D. removed. Thereafter the nitrification was not carried so far; during 10 years the nitrates were 15.3 p.p.m. with an air consumption of 1.16 cu. ft. per Imp. gal. (0.97 cu. ft. per U. S. gal.) or 711 cu. ft. per lb. of B.O.D. removed.

The operating data are summarized as follows for 1936 to 1946:

TABLE I.—Sewage Flows

Sewage Flows	Imperial M.G.D.	U.S. M.G.D.
Dry Weather—1936	40	48
Dry Weather—1946	58	69.6
Maximum Flow	455	546
Average Flow Received	62.4	74.9
Average Flow Treated by Act. Sl.	60.59	72.7
Average Flow Treated by Sed. Only	1.89	2.27

TABLE II.—Activated Sludge Plant Data

Item	Number	Detention Period Hours
Aeration Units in Use	9.99	6.60
Reaeration Units on Sludge	1.36	0.90
Total	11.35	7.50

Air Supply, Cu. Ft. per Min.	48.950
Air per Sq. Ft. Aeration Tank Surface, Cu. Ft. per Min.	0.165
Air per Imp. Gal., Cu. Ft.	1.16
Air per U. S. Gal., Cu. Ft.	0.97
Air per Lb. B.O.D. Removed, Cu. Ft.	711
H.P. per Million, (Imp.) G.P.D.	34
H.P. per Million, (U.S.) G.P.D.	28.3
H.P. Hr. per Lb. B.O.D. Removed	0.47
Volume of Return Sludge, Per Cent of Sewage	33.0
Suspended Solids in Mixed Liquor, P.P.M.	2360
Surplus Sludge, (Imp.) M.G.D.	0.92
Surplus Sludge, (U.S.) M.G.D.	1.10
Surplus Sludge, Per Cent of Sewage Flow	1.5
Surplus Sludge, Per Cent Solids	0.81

The air varied from 1.02 to 1.28 cu. ft. per Imp. gal. This includes all air used in various auxiliary channels and elsewhere. The suspended solids varied from 1,760 to 2,880 p.p.m.; and the return sludge varied from 29.8 to 37.3 per cent. A high return of sludge appears desirable. The normal volume of sludge in the aeration tanks is 15 per cent. From the surplus sludge, up to 50 per cent of clear supernatant liquid can be removed after 1 hr. settlement.

Mogden has an ample supply of gas for power purposes. Nitrification insures a comparatively uniformly dense sludge, freedom from bulking and a large reduction in the volume of the surplus activated sludge. It also provides a greater capacity to carry overloads.

The overall capacity of the aeration plant is normally 8 hr., based on the total tankage. Re-aeration has been practiced continuously, to maintain the sludge in good condition, to furnish a reserve for handling adverse discharges of industrial waste; and for storage.

On occasion in dry weather final effluent is returned to the influent end of the sedimentation tanks.

No clogging has occurred on the upper surface of diffuser plates except in the influent channel and near the inlet end of each aeration tank. However the plates in the reaeration units do not remain so free. A small amount of soot passes through the air filters and deposits on the underside of the plates, without seriously affecting the plate capacity. Rust however has accumulated in the cast iron plate boxes, partly from the supply pipes and partly from the boxes. After 3 yr. operation, chokage began to occur. The diffuser boxes were dismantled. The plates were reconditioned in a furnace at 800° to 900° C. The boxes were sandblasted and sprayed with zinc. The initial pressure was virtually restored. The original pressure rose from about 7 lb. per sq. in. to 8.4 lb. in 1941 and 8.6 lb. in 1942 and was reduced to 7.1 lb. in 1945.

By the enabling act, purification is required to a standard imposing a limit of 20 p.p.m. B.O.D. and 30 p.p.m. suspended solids for all flows up to a rate of 120 (Imp.) gal. per cap. per day. Thereafter all surplus storm water must be given sedimentation in tanks containing not less than 10 gal. per capita. This requires a maximum of 2 hr. settlement for storm

TABLE III.—Analytical Results in P.P.M.

Determination	Raw Sewage	Settled Sewage	Activated Sludge Effluent	Total Per Cent Removed
Oxygen absorption*	80.1	46.5	11.3	
Amm. nitrogen	38.0	39.6	15.3	
Alb. nitrogen	8.1	4.6	0.85	
Nitrous N			2.9	
Nitric N			12.4	
Chloride (as Cl)	103	103	99	
B.O.D. 5 days @ 18.3° C.	307	172	8.3	97.3
Susp. solids	238	69	7.0	97.1

* Oxygen absorption from acid $KMnO_4$, 4 hr. at 26.7° C.

water when the total sewage flow reaches 240 g.p.c.p.d. In short storms the impounded water is later returned for full treatment. In prolonged storms it goes to the river.

The plant effluent enters the River Thames near the head of the tidal prism. The average flow of fresh water from above is normally about 1,200 (Imp.) m.g.d., with a summer flow of about 400 (Imp.) m.g.d. In 1944, for the same 6 weeks the flow dropped to 60 (Imp.) m.g.d., and on one day to 28 (Imp.) m.g.d. No trouble resulted.

Sludge digestion is first practiced at Mogden for 25 days; then the sludge is pumped 7 miles to Perry Oaks for final digestion and air drying. The capacities of the two plants are:

Plant	Capacity Imp. Gal.	Cu. Ft. Per Cap.	Units	Type
Mogden	10,375,000	1.4	12	Heated
Perry Oaks	15,600,000	2.2	10	Unheated
	25,000,000	3.1		Lagoons

The side depth of all tanks is 32 ft. Forty per cent of the gas is produced during the first 24 hr. The sludge first enters 8 tanks with gas holder covers; after 17.3 days it passes to 4 tanks with fixed roofs and stirring mechanisms, where it remains for 7.1 days and is then pumped to Perry Oaks for secondary digestion of about 37.5 days. The total digestion period is about 62 days. In the winter the drying beds are loaded up, adding 15 (Imp.) m.g. capacity. Thus the total digestion volume at Mogden and Perry Oaks is 6.7 cu. ft. per cap. plus the drying beds (at 2.2 cu. ft. per cap.) making a total of 8.9 cu. ft. per cap.

Gas production has averaged 460 mil. cu. ft. per yr., with an average yield of 1.11 cu. ft. per cap. per day. The gas production is also 10 cu. ft. per lb. of organic matter in the raw sludge. The temperature in the gas holder tanks is 82.5° F.; in the fixed roof tanks 79.5° F. The daily loading per cu. ft. of capacity is:

	Dry Solids Lb.	Organic and Volatile Lb.
Gasholder tanks	0.14	0.12
Primary total	0.10	0.08

Loss of organic matter in raw sludge is 46.5 per cent at Mogden plus 5 per cent at Perry Oaks, making a total of 51.5 per cent. The raw sludge contains 75.8 per cent of dry solids as organic matter and 96 per cent water content.

The gas is composed of 68 per cent methane and 31 per cent carbon dioxide, with 680 B.T.U. per cu. ft. Ninety-five per cent of the output is used in the works for power, heat and operating vehicles. In 10 years the cost of 11,500,000 Imp. gal. of fuel oil for such purposes would have been £387,000 (about $1,548,000).

The gas holders contain about 5 hr. production. Tests indicate that after 9 years mild steel is more suitable than a copper bearing steel in such holders.

In 1945, inspection of the heating coils

in the sludge digestion tanks began, as their efficiency had declined. After cleaning, the original efficiency was restored.

Sludge pumping is carried out for 12 hr. per day with a velocity of 1.87 f.p.s. in the 12 in. main. The total head is 142 ft., of which 65 ft. is static, leaving 77 ft. for friction or 11 ft. per mile or about 1.4 times the friction loss for water. No change has occurred since 1936. Inspection shows no internal deposits. The pumps are horizontal two-cylinder, double-acting reciprocating type.

Sludge drying beds have been enlarged from 50 to 72 acres, providing 2.7 sq. ft. per cap. The beds are 18 in. thick, graded from coarse gravel to a 4 in. layer of fine sand. The depth of sludge applied ranges from 12 to 18 inches. This dries to a cake 3 to 4½ in. thick containing about 50 per cent moisture. The annual output of about 60,000 cu. yd. (40,000 tons) is lifted by an average of 10 men working 6 months. Since 1940, the entire output has been sold to farmers for about £6,000 per annum (about $24,000) or approximately 40¢ per cu. yd.

TABLE IV.—Power Station—Average 1938 to 1946

	Generators	Turbo-blowers
Number of Engines		
Gas operated (550 B.H.P.)	3	5
Oil operated (650 B.H.P.)	1	1
Annual output		
Kilowatt Hr.	5,092,000	
Compressed Air, Mil. Cu. Ft.		26,600
Engine Hr.	18,198	34,465
Average B.H.P. at Engine Coupling	403	534
Average Total Output		
Kilowatt	581	
B.H.P.		2,099
Maximum total output		
Kilowatt	910	
B.H.P.		2,280
Gas Cu. Ft. per B.H.P. Hr.	17.9	16.3
Cu. Ft. per Kilowatt Hr.	26.1	
Thermal Efficiency	23.3	25.7
Load Factors: Per Cent		
Station	38.7	63.6
Demand	63.8	92.0
Running	74.8	97.1

The power requirements of the works are about 26 million B.H.P. hr. per year of which 70 per cent is for compressing air and 15 per cent for operating the dry weather sewage pumps on the low level area. The sludge gas has been used since 1936 without purification. The maintenance of the engines is greater with gas as fuel than for oil, by reason of the higher exhaust temperature. Changing to oil ignition is expected to reduce maintenance.

Items	Pounds	Dollars
Operating Costs	36,514	146,056
Gas (Equiv. Value)	21,990	87,960
Net (Out of Pocket)	14,524	56,096
Miscellaneous Charges, Additional:		
Administration	2,296	9,184
Loan	12,199	48,796
Rates and Taxes	2,865	11,460
Gross Overall Cost	53,874	215,496
Less Credit Heat to Digestion Plant	6,725	26,900
Net Overall Cost	47,149	188,596

This net overall cost is 0.462 pence per B.H.P. hr. at engine coupling or 0.77 cents (12 pence = 20 cents).

In 1942 twelve motor vehicles (ranging from a car to a 5 ton truck) were equipped to run on compressed methane. The excess methane was used in making incendiary bombs.

Dry weather sewage pumps are electrically driven, automatically controlled, with an overall efficiency of 64 per cent (pump efficiency 70.3 per cent). Storm water is handled by Diesel engine pumps, which have each averaged under 100 hr. running per year. On a peak flow 5 engines (out of 6) may start within 30 minutes.

The construction cost of the Mogden-Perry Oaks works was £2,105,325; the main sewerage system and pumping stations £3,304,345; demolition of abandoned works £108,927. A total of £5,518,597 or about $22,074,388. The price level was that of 1932 to 1935. The money was borrowed as a 30 year loan on an annual repayment basis of 5.32 per cent (including interest and sinking fund).

The operating costs for the year 1938–39 are summarized in pounds (1 pound = $4.00):

Item	Operating	Loan Charges	Total
Sewage Treatment	50,601	38,201	88,802
Sludge Disposal	12,370	18,240	30,610
Unallocated	10,912	25,480	36,392
Total Treatment	73,883	81,921	155,804
Reserve Land, Plant, Housing, etc.	1,001	16,427	17,428
Total Works Cost	74,884	98,348	173,232
Credits			17,619
Net Total			155,613

(Note by Langdon Pearse. This net should be further reduced by £6,725 because no money passed for heating sludge digestion tanks.)

The net total annual cost per capita is 32.47 pence or $0.54 of which the operating cost was $0.31. The cost of treating the dry weather flow was 5 pounds 5 shillings 9 pence or $21.15 per m.g. (Imp.). With the cost of sludge disposal and unallocated works expenditure the cost is increased to $33.45 per m.g. (Imp.).

The rates of pay ranged from 1s. 4½d. ($0.275) per hr. for a laborer to 1s. 10d. ($0.37) per hour for a skilled filter or building trades worker. At present the costs have not risen materially; wages have increased nearly 50 per cent but the works are understaffed.

In 1939 the working staff of 258 included:

	Mogden	Perry Oaks	Sewers	General
Administration				30
Works Manager	1	1		
Shift Engineers (P.S.)	8			
Foremen	3	1	1	
Plant Operators	29	2		
Miscellaneous Trades	46			
Truck Drivers	4		4	
Laborers	58	35		
Miscellaneous	12	2	5	
Sewermen			16	
	161	41	26	30

Of the Mogden total of 161, operational duties absorb 51, of whom 38 were shift workers. Mechanical and electrical maintenance required 33. Building trades account for 23 men. Sixteen men were employed on landscaping and maintenance. On the site are fifty workmen's houses which have to be maintained.

Much of the discussion commended the design, construction and operation of the works. F. P. Cleff indicated that salvage of brewery waste produced 2 tons of edible protein per week. C. W. Steedman noted that a vitrified brick lining in a sewer subject to a velocity between 12 and 25 f.p.s. showed no wear. C. D. C. Braine indicated the value of the storage (about 35 m.g. (Imp.)) in the West Middlesex sewer system or about 18 hr. of dry weather flow. In 1930 most towns used water at the rate of 30 Imp. gal. per capita per day. In 1940 this increased to 40 Imp. g.p.c.p.d. and maybe in 1950 it will be 50 Imp. gal. per capita.

In closing the author indicated that ventilation of sewers is a matter of compromise. The industrial load as of 1939 was equivalent to between 300,000 and 400,000, rising to a maximum month of over 500,000. At West Middlesex a close control is kept on industrial wastes, so that a charge can be made based on cost per thousand gal. for treatment, plus charge for impurity load on activated sludge and cost per ton of solids. In general no trouble had been experienced with septicity in the sewers. The longest period of flow locally was about 10 or 12 hr. in dry weather.

The use of the activated sludge process was advantageous in the saving in area required, 6 acres at Mogden serving a greater population than 43 acres at Birmingham. Without this concentration, the Mogden scheme would have been impracticable. Activated sludge aeration tanks have been built as shallow as 4 feet. A maximum of 23 ft. proved disastrous. From 10 to 15 ft. are current in England and 15 ft. in the United States.

At Mogden storm overflows were almost eliminated. Storm water should be kept separate. The minimum velocity in the sewers should be above 2 ft. per sec. There are no main sewers in West Middlesex with velocities over 8 ft. per sec. The statutory requirement for stormwater tanks is 6 hr. capacity, based on dry weather flow. However the tanks were built for a future population of 2 million.

Sludge thickening tanks prior to digestion were discontinued because of ineffective results and odors.

LANGDON PEARSE

Melbourne and Metropolitan Board of Works. Report for the year ended June 30, 1946.

The annual water consumption has increased from 17,600 mil. gal. in year ending June 30, 1941, to 20,497 in year ending June 30, 1945. The per cent of metered consumption has risen from 55.2 to 59.4. Additional water supplies are projected.

Because of deepened channels in Melbourne harbor an inverted siphon will be rebuilt with its top 54 ft. below low water mark (instead of 35). The Board has been acquiring considerable excavating equipment to facilitate sewering new housing developments. The present Metropolitan Sewerage System is based on designs prepared in 1891 for one million population. It is now proposed to plan for two million. The Board will now provide sewers for areas with a population of 4 persons to the acre. This means the area must be one-quarter developed.

The sewage farm is 24 miles outside the city. Its area is 24,579 acres. The gross operating cost was £163,653. By systematic grazing of the pastures, the farm has derived a profit of £46,736 from the sale of cattle, sheep and horses, which reduces the cost of sewage disposal to a net of £116,917 for the year ended June 30, 1946, or 2 shillings per capita. This is higher than previously because of lower profits and deferred maintenance. Since 1942, farming operations have been confined to the production of beef. At the end of the current fiscal year there were 14,315 head of cattle on the farm.

Although water was supplied to 4,434 new houses, only 1,119 were completed and connected to the sewer.

LANGDON PEARSE

Report to West Basin Water Association, Los Angeles County, California. BY H. CONKLING. 36 pp. (July, 1946).

This report discusses various methods of overcoming the deficiencies of water supply in the South Coastal Basin. The only foreign source of water is the Colorado River. In 1947, 280,000 acre ft. will go to the ocean as sewage from Los Angeles County. This might be purified and put underground. The cost of placing purified sewage from the Los Angeles City North Outfall underground in the West Basin would be $13,000,000. Service charges on a bond issue plus operating costs would be $18.00 per acre ft. for delivery of 53,000 acre ft. per annum and $12.63 per acre ft. for 80,000 acre ft. per annum, the design capacity. A direct charge of $8.00 per acre ft. for 53,000 acre ft. annually, plus a tax of 45¢ on the 1945–1946 valuation, would service the project.

The report discusses eight possible sources of water, including the limited use of sea water and the rectification of sewage. Most of the nearby sources are nearing exhaustion. The two possible sources are rectified sewage and the Colorado River.

The system would include 110 wells (16-in. casing, 400 ft. deep) about 2,000 ft. apart and not less than 1,000 ft. from any wells used for water supply.

Analysis	Mineralization	
	Sewage P.p.m.	Colorado River Water P.p.m.
Alkalinity	108	105
Chlorides	119	103
Sulfates	129	366
Per Cent Sodium	54	81
Hardness	262	115

The water from the Colorado River would cost $35.32 per acre ft., or $108.45 per m.g. The cost of purifying and importing the sewage would be $18.00 per acre ft. for 53,000 acre ft. per annum.

Of the six appendices, No. 4, "Sewage Reclamation," by R. F. Goudey, is of interest to the sanitary engineer, for its detail in discussion of reuse of purified sewage. Goudey proposes preaeration (30 min.); short period sedimentation; aeration (4.5 hr. activated sludge); reaeration (2¼ hr. on return sludge); concentration tank for sludge to reduce moisture to 92 per cent; chlorination equipment for 20 lb. per m.g. avg. The air required is expected to be around 0.87 cu. ft. per gal. of sewage. The sewage analysis expected is around 300 p.p.m. suspended solids; 250

p.p.m. 5-day B.O.D.; and 100 p.p.m. grease. 53.5 miles of pipe are required for distribution of water, varying from 8 to 54 in. in size. Goudey concludes "water reclaimed as planned would be bacteriologically safe and minerally more desirable than any other imported water which might be available. However, the Colorado River water would be softer. Rectified sewage would be better for irrigation and industrial use. There should be no prejudice against such use of treated sludge." It is assumed that no charge is made for the Los Angeles sewage.

LANGDON PEARSE

Biological Treatment Plants of Achères and Experimental Sewage Station at Colombes. BY P. DESCROIX. *La Techn. Sanitaire,* No. 9–10, 65–66 (Sept.–Oct., 1946).

The plant at Achères consists essentially of primary settling, activated sludge, secondary settling, and separate sludge digestion, treating the waste of 500,000 people. The clarifiers have a detention time of 1.5 hr., the aeration is 6 hr. Raw sewage contains 230 p.p.m. suspended solids, and 170 p.p.m. B.O.D. The effluent contains 10 p.p.m. suspended solids, and 25 p.p.m. B.O.D. There are 4 Dorr two-stage digesters with a capacity of 3,000 cu. meters, one Nurnberg and one Prüss digester of 3,000 cu. meters each. Gas production is about 5,000 cu. meters per day with B.T.U. of about 620. Gas is utilized for power and heating.

The experimental station at Colombes consists of primary settling tanks, each 4,000 cu. meters/day: Imhoff tank, Mieder, Bamag, Dorr, and O.F.T.A. Activated sludge: Simplex, O.F.T.A., Dorr and Activated Sludge Ltd. Secondary settling tanks: Dorr and Hartley. For digestion: Dorr two stage (800 cu. meters cap.), O.F.T.A. (1,200 cu. meters). Further: one gas engine operating with gas directly from the tanks and 2 stations for compression of excess gas. All necessary equipment for measuring flows, energy production, etc., is available. The waste activated sludge is used for gardens.

W. RUDOLFS

Report of Commission on Studies of Urban Sanitation. BY M. GAULTIER. *La Techn. Sanitaire,* No. 11–12, 74–78 (Nov.–Dec., 1946).

Although separate sewerage systems have some advantages, a combined system is recommended. Velocity in the sewers should be at least 0.30 meters per sec. Preliminary treatment of sewage should consist of screening, grit removal or pre-settling. Primary treatment should comprise settling and digestion. Complete treatment, with exception of chemical coagulation, should consist of natural methods such as irrigation or fish ponds, or artificial means such as trickling filters or activated sludge, including digestion. In general, treatment should be sufficient (qualitative and quantitative) without interference with the natural self-purification processes in the receiving waters.

W. RUDOLFS

Percolating Filters for the Treatment of Sewage. BY ROBERTO ESPINOSA PARGA. *Ingenieria y Arquitectura* (Colombia), **VI,** No. 68, 20–24 (Mar.–April, 1946) and No. 69, 21–23 (May–June, 1946).

These two articles give a study of the general factors of design and operation of standard trickling filters according to American practice, with special attention to biologic action. The first article treats the general aspects of the filter and the second discusses the importance of biologic film and its place in the process of purification, followed by a study of factors of design, filter media, depth, loading, and influence of temperature, placement of medium, etc. Finally a rapid comparison is given of the two types of trickling filters and a general discussion of the importance and place occupied by trickling filters among the recognized processes of sewage treatment.

Obtaining a well nitrified effluent is principally a matter of cost, but it requires greater depth and low rates of application. It is not necessary to obtain a high degree of nitrification to produce a satisfactory effluent.

The efficiency of a trickling filter is affected mainly by the factors of loading and temperature.

The efficiency of oxidation is indicated best by the percentage of reduction of B.O.D. In a standard filter the reductions which may be obtained are:

5 day B.O.D.	55–75%
Suspended solids	10–30%
Bacteria	60–70%

Filter Material. If the size of the particles is large, the total area is small, but if the material is too small clogging will occur easily. For standard filters the size should run between 1.25 and 2.75 in. whereas in high rate filters the variation should be 2.75 to 3.95 inches. Material should be hard and non-disintegrating. The surface should not be smooth as film will not adhere. Size of medium should be uniform throughout, to obtain maximum ventilation of the filter.

Depth. The best depth depends on the character of the sewage, the rate of application and degree of treatment required. It is well known that with domestic sewage applied in the usual rates the quality of the effluent from beds 10 ft. deep is no better than from beds 7 ft. deep.

Purification effected per unit of volume generally decreases when depth exceeds 8.2 to 10 ft.

Drainage. Beds should be provided with free drains equal to 20 per cent of the area of the filter floor.

Application of Sewage (Dosing). The amount of purification effected by a filter depends to a great extent on the method of distribution. Today it is generally accepted that sewage should be applied continuously in fine drops rather than in small doses with large intervals of rest.

Distributors are of various types, as fixed sprays discharging vertically from above; rotary and moving distributors which are those generally employed in the majority of new installations.

Fixed nozzles are more economical for small filters and revolving distributors for larger ones. Best form is uniform at all times and areas of filter and application in form of fine spray which produces some aeration.

Fixed Nozzles. Require heads of from 6.87 to 10 ft. and were used extensively until recent years. Filter is usually rectangular with this type but usually only little more than 70 per cent of filter area is completely dosed. Usual size of nozzles is 7/8 in. but sometimes those of 3/4 in. and 1 in. are used.

Revolving Distributors. Circular filters used with this type and practically entire area is dosed uniformly. Revolving distributors are made for filters up to 164 ft. diam.

Loading. Loading permitted depends on characteristics of filter, strength of sewage and degree of treatment required, also on temperature, chemical and biological conditions, particularly when industrial wastes are included.

Hatch proposes expressing loading in values of B.O.D. in pounds per unit of filter volume, and tentatively suggests a standard of 250 pounds B.O.D. (5 day) per acre foot per day. This loading is equivalent to 135 grams B.O.D. (120° C.) per cubic meter (35.31 cu. ft.) per day. Others consider it more logical to express loading as the surface rate divided by the depth of filter. Loadings expressed by volume assume that lower strata of filter reduce same proportion B.O.D. as upper, which is not true, as it is verified that the greater proportion of B.O.D. is removed by the upper part of the filter.

The writer believes it is best to express loading as grams B.O.D. per square meter per day, which facilitates comparison of loadings. Loading daily in grams B.O.D. per square meter is equal to the daily dosage in cubic meters per square meter, multiplied by the demand in p.p.m. This can also be used to measure loadings in filters to be used to handle industrial wastes of an organic nature. B.O.D. daily demand is constant per capita. Prof. Phelps finds 112 grams per capita per day.

Removal of B.O.D. obtained in primary settling tank depends on type of unit, period of detention, arrangement of inlets and outlets, and temperature and nature of the sewage. If normal conditions are assumed, 35 per cent reduction B.O.D. in primary sedimentation tanks can be expected and B.O.D. per capita on filter is then 72 grams per day.

The table following gives comparative values of various expressions of filter loading.

Comparison Between Percolating Filters. Loading low rate filters 1 to 4 cubic meters per square meter per day and 20 to 25 cubic meters per square meter per day for high rate. High rate filters when not oper-

Grams B.O.D. Daily

B.O.D. per Cubic Meter	Cubic Meters per Person*	2 meters deep		3 meters deep	
		B.O.D. per Square Meter*	Square Meters per Person*	B.O.D. per Square Meter	Square Meters per Person*
80	0.900	160	0.4500	240	0.3000
100	0.720	200	0.3600	300	0.2400
120	0.600	240	0.3000	360	0.2000
135	0.533	270	0.2667	405	0.1778
150	0.480	300	0.2400	450	0.1600
300	0.240	600	0.1200	900	0.0800
500	0.144	1000	0.0720	1500	0.0480

* Assuming reduction in prim. sed. of 35 per cent B.O.D.

ated in series are generally deeper than common filters, usually 3 meters, with recirculation of effluent. Essentially the two types are equal but high rate effect is a coagulation, and because time of contact is very short, only the most easily oxidizable substances attacked. High rate filters produce a larger volume settleable solids than the standard type. These solids are more putrescible, of higher water content and settle more slowly in settling tanks than low rate solids.

Principal advantages of high rate are lower cost of construction, reduction of odors and flies, less obstruction of surface. Principal advantages of slow rate are better purification obtained in one stage, less sensitive in operation, cost operation less, less solids in effluent, elimination of recirculation.

Cites 9 references, 1 to Imhoff, balance all American.

E. B. BESSELIEVRE

Wartime Work of the Sanitary Engineer. By GORDON S. MCDONALD. *The Surveyor,* **105**, 61–62 (January 25, 1946).

World War I had its many problems of mud, filth, and contaminated water but these difficulties were increased by the highly mobile character of the recent war. The various campaigns called for careful planning for water supplies and other sanitation facilities. In Britain all branches of sanitation were affected by aerial bombardment.

The sudden influx of American and Dominion troops created numerous problems. Water supplies, drainage systems and sewage treatment works were seriously overloaded. In addition, forced location of large factories and airports in what were rural areas created problems in providing essential sanitary services. Many combat troops were located in camps and these camps had to be provided with complete utilities. No finer work was carried out during the war than that executed by sanitary engineers who safeguarded the health of troops and civilians in almost every part of the world.

The misleading use of the term "Sanitary Engineer" has influenced the general public to look upon the members of the profession as skilled craftsmen whose main occupation is plumbing. However, any attempt to change the name which the profession has carried for so many years would only lead to further confusion. It therefore rests with the profession to educate the public as to the correct interpretation of the title "Sanitary Engineer."

The paper closes with a discussion of the policies of the Institution of Sanitary Engineers with respect to admission to membership in the organization.

PAUL D. HANEY

Lime Treatment of Waste Pickle Liquor. By RICHARD D. HOAK, CLIFFORD J. LEWIS, CHARLES J. SINDLINGER AND BERNICE KLEIN. *Ind. and Eng. Chem.,* **39**, 131–135 (Feb., 1947).

The present scarcity of high-calcium lime suggested the studies reported in this paper, which describes methods for obtaining equivalent results on the treatment of waste pickle liquor with less reactive,

but readily available, dolomitic lime. Nine types of lime, two high-calcium and seven dolomitic, were investigated. It was found that the dolomitic limes reacted more slowly because of two related factors: low solubility of magnesium oxide and decreased reactivity of this component through overcalcination. Experimental data indicated that the calcium oxide reacts at a substantially greater rate than the magnesium oxide in dolomitic lime. This necessitates completing the reaction between the dolomitic lime and the pickle liquor with the least reactive portion of the lime at a pH where the solubility of magnesium oxide is quite low. Furthermore the magnesium oxide remaining at any time is less reactive than that previously consumed by reaction.

The reaction rate of a dolomitic lime can be increased by employing an excess of the lime. Roughly each 5 per cent excess reduces the reaction time one hour.

Raising the temperature increases the reaction rate considerably. (In practice pickle liquor may be treated before it has an opportunity to cool.)

Increasing the rate of oxidation of the ferrous hydroxide formed by the reaction markedly increases the reaction rate. This can be accomplished by more rapid stirring or by air injection. The sludge from dolomitic lime treatment is bulkier than that obtained from high-calcium lime treatment. This may be a serious disadvantage where sludge disposal is a problem.

Dolomitic lime has a basicity advantage over high calcium lime and from a cost standpoint can compete with the more reactive high-calcium lime even though certain expedients for increasing reaction rate may be necessary.

Nine figures. Three references.

PAUL D. HANEY

Industrial Wastes. Introduction. By SHEPPARD T. POWELL. *Ind. and Eng. Chem.*, **39**, 559 (May, 1947).

A number of industrial waste problems have been magnified with industrial growth and development and despite activities by various groups no broad corrective program has been developed. On a national basis sanitary and industrial waste pollution has outstripped the effort to maintain the national waterways in a reasonable state of purity. However, many industries are aware of their responsibilities and have expended large sums of money on research and treatment facilities.

The purpose of the symposium on industrial wastes presented before a joint session of the Divisions of Water, Sewage and Sanitation Chemistry and of Industrial and Engineering Chemistry at the recently held Atlantic City meeting of the American Chemical Society was to supply a comprehensive review of the corrective measures that have been taken by a diversified group of industries. No attempt was made to evaluate the responsibility of industry or to propose any national program for correction of pollution or to influence legislation now before Congress.

PAUL D. HANLEY

The Public Health Service and Industrial Pollution. By THOMAS PARRAN, M.D. *Ind. and Eng. Chem.*, **39**, 560–61 (May, 1947).

The U. S. Public Health Service has been interested and active for many years in water pollution abatement programs and is eager to continue its policy of cooperation with state and regional authorities.

At present, regulatory authority over stream pollution resides with the states. Standards for legislation are needed so that there will be reasonable uniformity from state to state. This could be achieved by the stimulation of regional authorities and interstate compacts. Here Federal grants and loans might be used to encourage research and the development and construction of treatment works.

The Public Health Service makes no recommendations at this time on the nature of regulatory federal stream pollution legislation. The decision as to the extent of federal police power in the control and abatement of water pollution is a matter to be determined by Congress. The Public Health Service is interested in seeing workable legislation, state and federal, enacted which recognizes the various phases of the problem and the interests and responsibili-

ties of all. The Public Health Service is interested in any federal legislation which includes the following: (1) provision of a federal agency to act as a coordinator; (2) authorization for appropriations to allow the federal agency to carry on the duties assigned to it; (3) provision of an advisory board to the agency; (4) permission for states to form interstate compacts; (5) authorization for appropriation of funds for allocation to states for the development of pollution abatement programs; (6) authorization for appropriation of funds for grants-in-aid for the construction of waste treatment works; (7) provision for continuing interest by the federal authority in the efficient operation of completed projects.

PAUL D. HANEY

State Responsibility in Stream Pollution Abatement. By ABEL WOLMAN. *Ind. and Eng. Chem.*, 39, 561–65 (May, 1947).

A review of state laws makes clear that they have been designed for two major purposes: (a) the protection of the public health, water supply, aquatic life, industry, recreation, and (b) the prevention or abatement of local or general nuisances. Basically stream pollution law within the states had its origin in the police power of the state to protect public health. Court decisions have sustained the state's authority to enact such laws as are necessary for the protection of the general health, comfort and welfare of the public. The greatest general difficulty with state laws on water pollution results from the exemptions or exceptions which many state stream pollution control laws have granted to municipalities, industries, and certain areas or rivers. Frequently unsatisfactory wording of the law has made demonstrated proof of violation difficult. Existing limitations, constitutional or statutory, upon bonding power are also of great importance since in many instances these limitations made it impossible to finance needed pollution abatement works. This difficulty can be overcome by legislation permitting sewer service charges and by exemption of bond issues for pollution abatement works from the limitation on bonded indebtedness. However, the secret to successful prevention and correction of abuse of streams does not lie in the mere existence of comprehensive legislative enactments. The existence of one or more informed officials with sufficient energy and wisdom to carry on a cooperative program of pollution abatement has, to a great extent, been responsible for the progress achieved in many states. A stream pollution statute alone will not produce clean streams. Action in this direction will result when there is an awareness and an acceptance on the part of the public and private industry of the fact that pollution cannot be continued indefinitely and when adequate administrative machinery is established for action toward the end of stream pollution abatement. In many areas the necessary administrative machinery is lacking. Financial considerations are worthy of study. Much progress could be made by developing improved techniques of financing sewage works installations.

The power of the state has been successfully established and the assignment of concurrent power in the field of stream pollution to the Federal Government, even on a contingent basis, may give rise to an even greater confusion than now exists. Much has been said by the advocates of central government control of the desirability of uniform application of standards of stream quality. It is doubtful whether such uniformity is applicable or desirable in this general field.

Ten references.

PAUL D. HANEY

Creation and Correction of Industrial Wastes. By SHEPPARD T. POWELL. *Ind. and Eng. Chem.*, 39, 565–568 (May, 1947).

Industry discharges wastes to streams that cover a wide range of organic and inorganic materials. These wastes may impart objectionable properties to the receiving waters. As population and industrial activity have increased, the quality of water in the nation's streams has deteriorated. Facilities to supplement natural methods of self-purification are needed. Public opinion in favor of pollution abatement is growing stronger.

Failure to control stream pollution is

due to a number of factors such as (1) the cost of treatment facilities, (2) lack of fundamental data upon which corrective processes can be based, (3) widely differing opinions on the desirable condition in which the streams should be maintained, (4) widely differing opinions concerning enforcement by legal measures, (5) conflicting opinions regarding local and watershed methods of control, (6) lack of cooperation among states, (7) exploitation of personal interests to the detriment of public interest. In any constructive program for stream sanitation thought should be given to the following considerations: (1) creation of an educational program on a national scale, (2) assembly of data on watersheds, (3) recognition of the economic necessity for properly employing the natural purification processes of streams in treating wastes, (4) lessening the present confusion among authorities responsible for stream sanitation, (5) mutual cooperation among industries on matters relating to research, (6) coordination of investigations and cooperative construction of treatment works by industrial groups, (7) arrangements between industries and local municipalities for disposal of industrial wastes.

In many cases the application of chemical engineering principles rather than sanitary or biological treatment processes is the best solution to the industrial waste problem. Plans for treatment of a plant waste should not be made until after every possibility for loss prevention or recovery has been explored.

The great barrier to a satisfactory solution of stream pollution is the high cost of treatment. The need for research can hardly be overestimated.

Probably no law dealing with stream sanitation can be passed that will meet the unqualified approval of all who are interested in the subject.

The problems of industrial waste pollution and their correction involve basic factors in our civic and economic life. The estimated annual value of products manufactured by industries which create wastes is 25 billion dollars and the number of persons employed in these industries is about three million. There could not be any violent disruption of such basic industries without serious consequences. The economic phase of the problem should receive careful consideration as regards enforcement of a stream pollution law within rigid time limits. Industry, however, should realize that it can no longer indefinitely create gross pollution.

In 1938 it was estimated that the cost of treatment works alone for the correction of gross industrial pollution would be nearly a billion dollars. Industry has already spent millions of dollars for industrial waste pollution abatement and will undoubtedly continue this program at an increasing rate during the next few years. The adequacy of the treatment works constructed will be dependent on intelligent planning and on a program of cooperation between industry and federal and state agencies which enforce existing or future laws.

PAUL D. HANEY

Atmospheric Pollution. BY W. C. L. HEMEON AND T. F. HATCH. *Ind. and Eng. Chem.*, **39**, 568–571 (May, 1947).

Pollution of the community atmosphere by various contaminants is an integral part of the industrial scene and will never be entirely eliminated. Generally the facts do not indicate that the common atmospheric pollutants are hazardous to health. The phrase "hazard to public health" should be transformed to "public nuisance." Atmospheric pollution does not have to be injurious to health to be socially undesirable.

The civic trend is to require more air pollution control on the part of industry. Management generally desires to reduce contamination if it is convinced that there is excessive pollution from plant operation and if it is economically feasible to prevent the pollution. Industry should take an active position in this field and sponsor needed research. Close cooperation with public agencies is also advisable to ensure that any regulations passed are based on sound principles. Practical standards must give due weight to the factors of tradition of the community, its social and economic status, and the history of the industry. The most difficult problems in the control of atmospheric pollution are economic and there is a great need for the development of more economical control methods. Any standards developed will

have little practical meaning until they are translated into terms of what industry must do to meet them.

Pollutants may be classified on the basis of outstanding physical properties, as gases and vapors, dusts, fumes and smoke, and mists.

Air pollution may be controlled by chemical engineering techniques and by tall stacks (1,000 ft. in certain situations). Meteorology can aid in the selection of new plant sites.

Four references.

PAUL D. HANEY

Pollution Control at a Large Chemical Works. BY I. F. HARLOW AND T. J. POWERS. *Ind. and Eng. Chem.*, **39**, 572–577 (May, 1937).

The Midland, Michigan plant of the Dow Chemical Company manufactures over 400 chemicals in 500 buildings. Wastes include 200 m.g.d. of water, 70 tons of refuse and millions of cu. ft. of vented air.

Polluted waste waters are broadly classified as brines, clear waters, special wastes, phenolic wastes, and general organic wastes. About 1 m.g.d. of waste brine results from bromine, calcium chloride, Epsom salts, and magnesium manufacturing processes. This brine, about eight times as strong as sea water, is stored in some 400 acres of ponds and released during periods of high stream flow. Pond dikes are made of clay and are provided with concrete and steel outlet structures. During discharge periods the river immediately below is kept under 5,000 p.p.m. as sodium chloride to protect fish life. Water works at two cities downstream are protected by fresh water storage capacity and conductivity recorders. This method of brine disposal was adopted after attempts to return brines to subsurface formations had failed.

Clear condenser waters represent about 60 per cent of the total volume of liquid wastes. These are discharged direct to the river. Condenser losses are kept to a minimum to permit direct discharge of these wastes to the river.

Special wastes are those which require special handling and which cannot be mixed with other plant wastes. These are handled by a variety of methods including recirculation, steam distillation, treatment with activated carbon and chlorination. Inorganic acid wastes are discharged directly to the river where sufficient alkalinity exists to neutralize them. Some chlorinated phenolic wastes require special treatment. Chlorine substitution in the para position seems to render these compounds difficult to treat biologically.

One of the most important units in phenolic pollution control is the strong-waste storage pond. After ponding the strong phenol waste is mixed with weak waste and neutralized with lime in preparation for treatment by biological oxidation. After clarification biological oxidation is accomplished on four 142-ft. trickling filters. The filters are 9.5 ft. deep and the medium is 2.5–3.5 in. blast furnace slag. Motor driven rotary distributors are used. The temperature of the mixed waste leaving these filters varies from 53° to 95° F. and the pH is kept above 6.1 and below 8.0. The phenol concentration for normal feed varies from 30 to 50 p.p.m. Higher concentrations are recirculated. Phenol removal is from 4.29 lb. per 1,000 cu. ft. at 56° F. to 9.0 lb. per 1,000 cu. ft. at 83° F. with a feed rate of 10.2 m.g.a.d. B.O.D. removal varies from 15.8 lb. per 1,000 cu. ft. (56° F.) to 27 lb. per 1,000 cu. ft. (83° F.).

The filters have been in operation over five years and are serving as effective oxidation units. The faces of the stone are covered with a slime containing millions of bacteria. Oxygen for the filters is derived from air passing through the beds countercurrent to the water.

The filter plant effluent is further treated by the activated sludge process. The capacity of the activated sludge plant is about 1,700 lb. per day of phenol or 5,000 lb. per day of B.O.D. Effluent ponds serve to oxidize further the soluble organics and to settle suspended biological flocs before discharge to the river.

General organic wastes have a volume of about 50 m.g.d. The oxygen demand of these wastes approaches 28,000 lb. per day and the threshold odor is near 5,000. The wastes are measured, screened and passed through a grit chamber and a clarifier. Following the clarifier are two parallel aeration tanks and two final settling tanks. Aeration is accomplished by water jet-type

diffusers located 2 ft. from the bottom of the tanks. At present there are 362 jets in each of these basins diffusing 7,000 cu. ft. of air per minute. Water requirements for the jets are 8,500 gal. per min. at 18 lb. per sq. in. pressure. This system will allow the absorption of almost 30,000 lb. per day of oxygen using about 400 horsepower.

The plant effluent is clear with a slight color. The odor is reduced 75 per cent and the oxygen demand 90 per cent.

Refuse disposal consists of burning combustible materials and developing fill areas for non-combustibles.

The Dow Company is continuously working toward the elimination of three types of atmospheric pollutants: (a) odors that cause discomfort or reduce property values, (b) irritants to the eye, ear, nose, throat or skin, (c) aerosols which may create fogs or unhealthy working atmospheres.

In the case of a synthetic rubber plant it was deemed best to vent the entire building and process vents to a system which delivered the air to the force draft fans of a nearby power plant. This was very effective.

Small flows of concentrated gases are burned directly or absorbed through granular activated carbon. The problem of wet, odorous stack gases from dryers and flakers has not been satisfactorily solved in all cases.

Irritant gases are prevented from escaping to the atmosphere by venting through scrubbers containing a proper absorbent. Automatic analyzers on vent stacks have helped control losses.

Dry dusts are collected through bag-type filters or gravity separators. Boilers are equipped with fly-ash control.

Ten photographs and figures. Three references.

PAUL D. HANEY

Industrial Wastes—Pharmaceutical and Biological Plants. By E. L. KNOEDLER AND S. H. BABCOCK, JR. *Ind. and Eng. Chem.*, **39**, 578–582 (May, 1947).

Biological and pharmaceutical laboratories and plants have been growing steadily for years but their growth rate increased markedly during the recent war. This growth has steadily increased the quantities of waste produced. The pharmaceutical plant under discussion is located on a watershed which drains to streams from which potable water supplies are taken. The plant is therefore waste conscious and looks upon disposal problems as being as important as process problems. A manufacturing process is not considered workable until a satisfactory method for dealing with its wastes has been developed.

The plant industrial sewer system collects various industrial wastes and small amounts of sanitary waste and delivers them to a small preliminary waste treatment plant. This plant consists of a rotary screen and settling tank, two holding tanks of about 100,000 gal. capacity, a degreaser, an aerated flocculator, a trickling filter and a chlorinator. The chlorinated effluent from this plant after pH adjustment to 7.0–7.5 is discharged to a municipal sewage treatment plant.

Certain wastes which cannot be satisfactorily handled by the sewage treatment plant are disposed of by drying followed by sale or incineration of the dried product.

Complete destruction of certain types of waste is desirable and incineration has been adopted for disposal of noxious, dangerous or resistant combustible materials even though drying may be required ahead of incineration.

Wastes from the manufacture of calcium pantothenate are discharged to holding tanks where they are treated on a batch basis with calcium hypochlorite prior to slow discharge into the industrial sewer.

Wastes from riboflavin manufacture are handled by spray drying followed by incineration.

Penicillin wastes are especially troublesome and will cause great difficulty in a domestic sewage treatment plant. These wastes cause trickling filter clogging and interfere with sludge digestion. The B.O.D. of the wastes is high (several thousand) and oxidation is slow and difficult. The most successful disposal method involves stripping for amyl acetate recovery. The still slops are then combined with filter cake solids, dried and incinerated.

Large animal carcasses are processed in the tankage plant. Small animal carcasses are destroyed in smokeless and odorless incinerators located in various buildings

where small animals are used for testing purposes.

Powder wastes from tablets and capsules are salvaged to the extent of about 90 per cent of the fines originally lost, in centrifugal separators. The balance is caught in a bag collector system. The contents of the bag collectors are destroyed by incineration.

It is possible to eliminate waste nuisances from such manufacturing plants at not too great expense provided the recovery and sale or utilization of by-products is kept in mind. By-products will probably never be profitable standing alone but they may contribute toward the cost of preventing waste nuisances.

Four photographs and figures.

PAUL D. HANEY

Industrial Wastes—Cornstarch Processes. By R. E. GREENFIELD, G. N. CORNELL, AND W. D. HATFIELD. *Ind. and Eng. Chem.*, **39**, 583–588 (May, 1937).

In the early days of the cornstarch industry considerable losses to the plant sewers occurred. The stream pollution effect from a small starch factory could assume the magnitude of that from a city of half million. In the early 1920's real progress was achieved in waste prevention and the recovery systems developed proved of economic advantage to the plants using them and at the same time provided stream pollution relief. The recovery process was based on the re-use of the milling process waters in the closed circuit. This led finally to the development of the "bottled up" process. Losses from a plant of this type result normally from the failure to achieve a balance between water input and output and as entrainment from steep water evaporators and, abnormally, as spills resulting generally from breakdowns.

The original sewage treatment plant at Decatur, Illinois, was placed in operation in 1924 and consisted of grit chambers, Imhoff tanks, three acres of trickling filters, and secondary sedimentation. The design population was 60,000 but during the design and construction period of the intercepting sewers a tributary cornstarch works grew at an unexpected rate and the sewage received at the plant in 1924 had a population equivalent exceeding 300,000. The Sanitary District of Decatur, Illinois, started a sewage testing station to find out if the sewage-waste mixture could be treated by a short-period activated sludge process followed by trickling filters. At the same time the starch manufacturing company began the study of waste recovery processes. These studies resulted in recoveries by the industry which are described in detail in this paper and the construction by the Sanitary District of a short-period activated sludge plant which increased the treatment plant capacity to 150,000 population equivalent.

A number of years of operation of this plant proved that when residual corn products wastes are mixed with about an equal volume of domestic sewage, they can be satisfactorily treated by the activated sludge process, on trickling filters, or on a combination of the two in series. Detailed information is presented regarding the loading of various units in the combination activated sludge trickling filter plant.

Five references. Four figures.

PAUL D. HANEY

Rubber Industry. By G. M. HEBBARD, S. T. POWELL, AND R. E. ROSTENBACH. *Ind. Eng. Chem.*, **39**, 589–595 (May, 1947).

The chemical, petroleum and rubber industries in the United States made only a moderate effort to develop synthetic rubbers prior to 1940. In that year the Rubber Reserve Company was created by the RFC to stock-pile natural rubber against a possible war in the Far East. By the next year, however, the new organization had requested plans for plants to produce 10,000 tons of synthetic rubber annually. Events of the war necessitated rapid upward revision of the original figure, with the result that the rubber program was eventually producing 1,000,000 tons of synthetics annually. The program required the construction of 53 plants of various types.

A wide variety of organic chemicals is used in the production of intermediates and final products in this industry. While the chemical characteristics of these compounds are well known in their reactions in the plants, their effect on streams is not known in detail. The hydrocarbons used in the processes are only slightly soluble in water, but certain of them can be

oxidized by bacterial activity and thus create an oxygen demand in the stream.

The Rubber Reserve Company early adopted the principle of correcting wastes before complaints developed, and a preliminary policy was established to protect receiving streams against pollution. Waste treatment was based on three principles, namely, (1) re-use of potential waste solutions, or processing them in auxiliary recovery equipment, wherever possible; (2) treatment in regional facilities of wastes from unit operations before discharge to sewers, with by-product recovery where feasible, and chemical treatment where necessary; and (3) collection of combined wastes from all sources in a gravity separator, but with provision of separate treatment for sanitary wastes, cooling and storm water.

Treatment plant operations chiefly involved gravity separation, plus coagulation of latex, soaps, and other materials. The equipment varied from plant to plant, but, in general, tanks were provided for decantation, and fractionating columns for reduction of waste volume and recovery of substances miscible with water. Detention time in gravity separators varied from 0.7 to 7.0 hr. and averaged 2.5 hours. Rubber crumbs of small size were recovered in vacuators to reduce the size of settling basins. Aeration was sometimes resorted to to reduce odors and oxygen demand. Final separators usually followed a modified A.P.I. design.

As of March, 1946, $13,500,000 was spent for waste treatment at 41 plants in 18 geographical areas. It is anticipated that additional treatment facilities will be needed at those plants continuing in operation.

Flow-sheets are given for GR-S, butadiene, and styrene waste treatment plants, and five tables list plant sizes and locations, principal raw materials in the manufacturing processes, and waste character for the three types of plants illustrated.

RICHARD D. HOAK

Recovery of Fermentation Residues as Feeds. BY C. S. BORUFF. *Ind. Eng. Chem.*, 39, 602–607 (May, 1947).

As of 1946, 78 per cent of the potential recoverable values from grain distillers' stillage was being converted to dried feeds and 14 per cent was being sold as wet feeds, leaving only 8 per cent unrecovered. This great advance over the 8 years preceding the war, when only 11–20 per cent was recovered, resulted from the increased demands for all types of feed during the war, and from Government insistence on the installation of the necessary equipment. Today this is a profitable operation at medium to large distilleries, and even the small distiller can show a profit with a properly engineered and operated installation. There is a potential recovery of 340,000 tons of feed from the beverage distillers alone, but this figure will probably reach a peak of 750,000 tons per year in 1947 and 1948 because of capacity operations to replace aged stocks of whiskey. In the near future it is likely that all industrial alcohol will be fermented from molasses, or made synthetically.

The recovery process consists of fine-screening the stillage to recover grains which may be pressed and passed through rotary driers to be sold separately as light distillers' grains. The screened stillage (0.8 per cent suspended solids) is normally concentrated in multiple effect evaporators to a viscous material containing 25–35 per cent solids. If the screened stillage is first centrifuged, it may be concentrated up to 50 per cent solids, and special treatment can provide even higher concentrations. The concentrated solubles may be combined with the screenings and dried grains to produce dried dark distillers' grains. The evaporated syrup may be dried on drum driers to produce distillers' dried solubles, and manufacture of this product has increased very rapidly since 1939. The protein, fat, vitamin content, and bulk of dried grains make them especially valuable in dairy rations. The dried solubles are a valuable feed supplement, particularly in poultry and certain swine rations.

Some stillage has been digested thermophilically for a number of years. Broad irrigation and lagooning are practiced to a limited extent, at a rate of 5,000 to 10,000 gal./acre/day. Stillage is the only waste from grain distillers that is important in volume and strength; it has a B.O.D. of 15,000 to 20,000 p.p.m. Equipment cleanup washings are usually run to the sewer.

Stillage from alcoholic fermentation of

molasses averages 5 per cent total solids (4 per cent organic), and has a B.O.D. of 22,000 p.p.m. Most of these wastes are concentrated to 50–60 per cent solids and substituted for molasses in stock feeds. For each 2.4 gal. of molasses mashed, 6–8 lb. of dried stillage is recovered. The yeast waste has a B.O.D. of 7,000–14,000 p.p.m. and is too low in solids and food value to justify recovery. A process of stage digestion has been developed which reduces its B.O.D. to about 1,000 p.p.m., and, when diluted with 15–20 parts of condenser water, yields an inoffensive effluent that may be discharged to a river.

Stillage from acetone-butanol fermentation of molasses is more dilute, but has a B.O.D. of 7,000–11,000 p.p.m. This material can be disposed by anaerobic digestion followed by aerobic stabilization. Most of it, however, is evaporated, dried, and sold as dried fermentation solubles. It is a valuable feed supplement because of its high vitamin content.

Brewers' wastes are mainly liquor pressed from wet grain, yeast recovery liquor, and miscellaneous washup wastes. Waste water from an average brewery has a population equivalent of about 13/bbl. of beer, on a B.O.D. basis. Yeast recovery is profitable, 0.1 lb. of dried yeast being recovered per barrel of beer. From 25 to 27 per cent of the original weight of the grain is recovered as dried brewers' grains, and an equivalent amount is sold as wet grains. Hops residues are usually burned under boilers. Concentrated brewers' wastes are too dilute to be evaporated, and, while they are not susceptible to chemical treatment, they can be treated alone or with domestic sewage by biological oxidation.

Winery wastes consist of stems, pomace, lees, and stillage. The first two of these, amounting to 15–20 per cent of the original weight of the grapes, are spread on vineyards for their fertilizer value. Lees is rich in potassium bitartrate, and about 1,300,000 lb. of this compound was recovered from this source in California in 1944.

Winery stillage is the most difficult waste to dispose of. The most common method is storage in settling basins. Frequently overloaded, the resulting decomposition produces foul and nauseating odors. Greater basin area would reduce this nuisance. The increasing consumption of brandy and dessert wines indicates that the problem of disposing of winery stillage is becoming more and more acute. The Wine Institute has initiated research to achieve maximum efficiency in disposing of winery wastes.

This article contains a wealth of factual information, including a number of tables and charts giving the composition of the various wastes and the by-products recoverable therefrom.

RICHARD D. HOAK

Citrus Canning Industry. By ROBERT R. MCNARY. *Ind. Eng. Chem.*, 39, 625–627 (May, 1947).

Growing, marketing, and processing citrus fruits forms Florida's second most profitable industry (tourist trade ranks first). In the early days the fruits were marketed only as a fresh product, and the only waste was spoiled fruit and culls. Those were either dumped on wasteland or returned to the groves and ploughed under to add humus to the soil. Only a limited amount can be disposed of in this manner, however, and as the industry expanded through the introduction of canneries, new disposal methods were sought.

Dehydration plants now convert about 60 per cent of the citrus waste into cattle feed, 80,000 tons having been produced in 1945–46. All of this waste cannot be processed because (1) some plants are too small to operate a dehydrator or too far from a feed mill; (2) some fresh peel is always fed to cattle; (3) operations are too light at the beginning and end of the season to warrant operating a dehydrator; and (4) the capacities of the feed mills are too low during the peak periods.

Production of dried citrus feed was a boon to the canner, but it created a new problem in disposing of the press liquor. The fresh waste contains 82 per cent water which must be reduced to 8 per cent in the feed, and direct evaporation was too costly. Pressing reduces the water to 72 per cent or less, but the press liquor contains 12 per cent dissolved solids, of which 5–7 per cent is sugar. This waste has an oxygen-consumed value of about 40,000 p.p.m. and is difficult to dispose of unobjectionably. It can be treated with domestic sewage as long as it is not pres-

ent in disproportionate quantity. Unfortunately, the peak of canning operation occurs during the height of the tourist season, and, thus, excessive treatment plant capacity is required for January and February. Press liquor cannot be discharged to surface water, either fresh or salt; to deep wells; to lagoons; or back to the groves.

Press liquor can be successfully concentrated to citrus molasses of 70–75 per cent total solids. This syrup is not fit for human consumption but forms a valuable addition to stock feed because of its high carbohydrate content. This waste treatment method has been quite profitable in recent years due to the sugar shortage, and the bulk of the press liquor is so treated today. Attempts have been made to produce a bland syrup suitable for baking or candies, but so far they are only in the laboratory stage.

Industrial alcohol could be made from the press liquor, but competition from producers of blackstrap molasses probably would be ruinous. Studies are in progress to use press liquor for growing feed yeast. Such material would be valuable for addition to feeds because, while dried citrus feed contains only 6 per cent protein, yeast contains nearly 50 per cent. The effluent from a large government pilot plant producing yeasts has shown a 75 per cent reduction in oxygen-consumed value.

Ordinary canning wastes are not as concentrated as press liquor, but are much larger in volume. Their oxygen-consumed value is generally below 5,000 p.p.m. One large plant uses 90 per cent of this waste to cool cans after pasteurization, but the other 10 per cent must be disposed of by sanitary treatment. This waste has a minimum population equivalent of 25 per ton of fruit packed, on a total solids basis, and about 8, on a B.O.D. basis. The diluted waste can be handled on natural sand beds where several beds can be rotated to allow for a rest period, and where the ground-water level is not too high. Trickling filters have been used successfully but their cost has been found to be prohibitive. Where the wastes are sufficiently dilute they can be discharged inoffensively into large lakes if care is taken to distribute them intelligently.

The inescapable conclusion is that citrus wastes will continue to increase and disposal problems will become more acute. The necessity for continued research is evident because there are a number of possibilities which have had little or no study. In time, these may be developed profitably.

RICHARD D. HOAK

Textile Industry. BY JOHN C. GEYER. *Ind. Eng. Chem.*, **39**, 653–656 (May, 1947).

Developments of the past 60 years have shown that liquid textile wastes can normally be treated by processes suitable for domestic sewage. The treatment is expensive and difficult and it does not always yield effluents of the desired quality. That this is so is not attributable to lack of research, for much excellent work, especially that sponsored by the Textile Foundation, has been done in all textile producing areas. The wastes are extremely variable, ranging from the chemically strong, deterging wastes to the relatively weak rinse waters. Wherever possible, textile wastes should be combined with domestic sewage for municipal treatment, as this is simpler, cheaper, and affords better control. Where a mill operates its own treatment plant, equalization plus chemical treatment is usually employed. Mechanical or biological filtration is used where a high quality effluent is demanded. Precipitation and settling plants cost from 10 to 20 cents per 1,000 gal. of waste.

The most serious textile wastes are those produced in deterging and scouring operations. Wool scouring waste is an evil, greasy liquid, highly alkaline and putrescible. Its character is shown in the table below.

	Parts per Million by Weight		
	Maximum	Minimum	Average
Grease	25,800	3,000	8,650
Suspended matter	30,300	2,400	11,520
Oxygen absorbed*	7,400	398	1,830
Alkalinity	29,400	3,430	6,780

*Oxygen absorbed in 4 hours from N/8 permanganate at 90° F.

Cotton kier liquor contains fats, waxes, resins, starch, etc., removed from the fiber by boiling with strong caustic under pressure. The average composition of kier liquor from the one-boil method is given below.

	Quantities per 100 Lb. Goods		
	Kier	Rinse	Total
Gallons	33	83	116
Total solids, lb.	4.78	4.11	8.89
B.O.D., lb.	0.81	0.79	1.60
Population equivalent	4.82	4.84	9.66

Silk degumming liquor, a thick soapy liquid of almost jelly-like consistency, contains sericin from the fiber, soap, and other detergents. Wastes from a plant using two washes after the boil-out, average as follows.

	Quantities per 100 Lb. Goods
Gallons	850
Total solids, lb.	30.7
Volatile solids, lb.	22.7
Suspended solids, lb.	3.7
B.O.D., lb.	6.99
Population equivalent	44.24

Steeping and fermenting (retting) of flax straw to remove the pectose produces a highly putrescible waste that is usually ponded at the flax farm until it has decomposed sufficiently to permit safe discharge to a stream.

The bleaching and scouring of cotton produces a waste similar to, but weaker than, kier liquor. Where bleaching and kiering are combined, the waste has the following average character.

	Quantities per 100 Lb. Goods
Gallons	976
Total solids, lb.	19.66
Population equivalent	6.60

Dye wastes are large in volume and variable in quality with respect to difficulty of treatment and damage to streams. Sulfur dye wastes are alkaline, highly toxic, and contain sodium sulfide. They damage streams, are difficult to treat, and upset sewage treatment plants unless properly proportioned. Vat dye wastes are alkaline and contain reducing agents which cause a high chemical oxygen demand. Their character appears below.

	Quantities per 100 Lb. Goods	
	Sulfur	Vat
Gallons	545	1890
Total alkalinity, p.p.m.	1511	1675
Population equivalent	35.69	12.86

Process costs and expense of waste treatment can be reduced by reducing the waste volume. This can be done by reusing weak wastes for make up or for addition to more concentrated baths; by retention of used baths for restoration to strength; by employing counterflow methods; and in other ways. Useful byproducts cannot be recovered except from strong chemical wastes. Wool scouring waste can be reduced by removing grease and dirt before scouring. The high dilution of dye wastes makes dye recovery impractical, but dyes can be saved by retaining spent baths and making them up to strength, and by other expedients. Good housekeeping should be the watchword for waste reduction.

Treatment processes frequently involve separation, equalization, co-precipitation, chemical treatment, filtration, and biological treatment; of these, chemical treatment is the most widely used. The coagulants used are lime, ferrous sulfate, ferric sulfate, aluminum sulfate, ferric chloride, calcium chloride, and sulfuric acid. Ferrous sulfate and lime in combination usually work best and are the most economical. Batch-type plants are the simplest and cheapest where waste volume does not exceed about 250,000 gal. per day. Above this figure continuous equipment is usually dictated.

Treatment of textile wastes with municipal sewage is usually employed where the local facilities are adequate. Equalization and regulation of the flow at the mill are essential; otherwise the wastes will interfere with the operation of the sewage plant. Where wastes are strong in proportion to the sewage dilution factor, or are toxic to sewage bacteria, some degree of pretreatment at the mill must be used.

This article contains diagrammatic sketches of three types of textile waste-

treatment plants, and includes much more data than is given here.

RICHARD D. HOAK

Refinery Waste Disposal—XVI. Four Factors are Major Controls in Design of an Economical Oil-Water Separator. BY W. B. HART. *Petroleum Processing,* 2, 282–290 (April, 1947).

Certain factors control the design of sedimentation equipment. These are:

1. The type of flow through the equipment.
2. The shape of the equipment cross-section.
3. The size of the oil globule and its rate of rise.
4. The rate of globule rise versus practical separator length.

The effective separation of oil from water by sedimentation depends on a type of flow whose turbulence is too small to overcome the buoyancy of the oil globule. Laminar flow would be ideal, but it cannot be attained in practice. While Reynolds' number is the best criterion for estimating the relative turbulence, there is no mathematical method for predicting an absolute degree of turbulence. Since the level of turbulence that will interfere with globule buoyancy cannot be calculated, it is necessary to employ experiment and observation.

A glass separator (12 in. wide × 30 in. long × 10 in. deep for 6 in. flow depth) was constructed for laboratory study of turbulence. Dye solutions were introduced for observation of type of flow. No matter how carefully the dye was introduced, laminar flow was never attained. It was established that excessive turbulence occurred at a calculated velocity of 0.0086 ft./sec. The effect of turbulence on oil globules was next determined by introducing a suspension of oil made by shaking 24° A.P.I. oil with water. It was found that velocities in excess of 0.0091 ft./sec. produced turbulence which carried the smaller globules along.

Based on these experiments, a pilot separator was designed with a width of 8 ft., and other dimensions in proportion as calculated from the laws of hydraulic similitude. These calculations also determined the range of Reynolds' numbers for the experimental separator. When flows based on these numbers were applied to the separator they resulted in pronounced eddy currents around some of the accessory equipment. This necessitated computation of a new range of Reynolds' numbers and their correlation with flows permissible in a plant-size separator.

Certain practical features had to be considered before this could be done. Basin cleaning mechanisms available at the time limited the width of separators to 20 ft., and this width was accepted as standard. The desirable flow depth should be half the width, but, as many refineries are located in low areas bordering on water, with a consequent high water table and sewers less than 5 ft. below grade, a practical compromise was reached by adoption of a flow depth of 8 ft. This was a deviation from the ideal channel cross-section, but it could be shown that the deviation was not serious. A plot was then prepared for Reynolds' number versus the A.P.I. gravity of the suspended oil. For correlation of standard cross-sections (20 ft. × 10 ft.) with Reynolds' numbers for other flow depths of standard width, a plot was prepared of per cent standard cross-section area versus per cent Reynolds' number for a standard cross-section. These two plots permitted a graphical determination of the proper Reynolds' number for any flow-depth of standard width. It must be emphasized that the capacity of a separator is governed by the average velocity of a vertical transverse section of flow, and not by cross-sectional area. Also, the amount of oil in the waste water has a negligible effect on separator capacity. These principles are illustrated by formulas and examples.

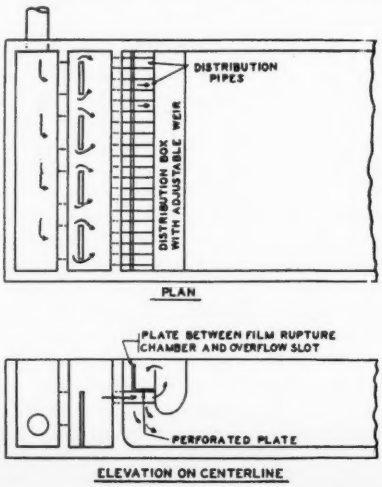
Every effort must be made to design a separator that will maintain proper flow character. Perfect distribution of flow is impossible in any practicable separator because (a) in viscous flow the fluid is retarded by the walls; (b) movement of suspended particles causes disturbances; and (c) flow cannot be introduced practically in a manner that will not cause some disturbance.

Although the desired type of flow could be attained in the lower reaches of a sufficiently long channel, construction of such a separator would be uneconomical. Therefore resort must be made to stilling chambers to bring about quickly the proper type of flow. Unlike flow in a pipe

where the pressure is equal on all sides, the pressure in a channel varies from atmospheric at the top of the flow to atmospheric plus hydraulic head at the bottom, and flow velocity varies with distance from the sides and bottom. The shape of the velocity curve will vary with the volume of liquid flowing, and Reynolds' number control of velocity will prevent overloading. In a properly designed separator practically all of the fluid will flow forward tranquilly, because the critical depth will occur only a few inches above the bottom, and it is into this region that the discharge from a stilling chamber should be evenly distributed.

Stilling can be accomplished in several ways, but stilling in steps is the most economical method. The velocity head of the fluid from the influent sewer is dissipated by impinging the stream against a baffle, which creates eddy currents. These currents are stilled by dividing the flow and introducing it into a stilling basin equipped with an adjustable sharp-edge weir which discharges the fluid into a second chamber filled with 2½ in. Raschig rings resting on a perforated steel plate, to serve as a film-rupture chamber. From the film rupture chamber the fluid passes into the separator, where the oil globules rise to the surface and are skimmed by travelling flights while the clarified liquor passes over a weir at the far end of the tank.

This article contains a number of figures, of which one is reproduced here to illustrate schematically one design for an oil-water separator. Space does not permit inclusion of details of design, and anyone contemplating such a separator should refer to the original article.



RICHARD D. HOAK

Refinery Waste Disposal—XVII. Designing Primary Section and Accessories of an Effective Oil-Water Separator. BY W. B. HART. *Petroleum Processing,* **2**, 471–477 (June, 1947).

An oil-water separator comprises a primary and a secondary section. The sedimentation basin, which extends from the downstream wall of the distribution box to the upstream side of the oil retention baffle, occupies the largest proportion of the primary section. The chief function of this section is not complete oil removal, but the removal of any conditions which would affect complete oil removal in the secondary section. The major portion of the free oil will, however, be separated in the primary section.

The division of a separator into two sections has often been justifiably questioned, but, except in unusual cases, the divided separator provides the greatest efficiency at the lowest cost in the long run.

The important factors in separator design are (a) temperature of waste flow; (b) density of oil to be separated and retained; (c) density of water-portion of waste; (d) absolute viscosity of oil to be separated and retained; (e) absolute viscosity of water-portion of the waste; (f) Reynolds' number to be used; (g) hydraulic radius of flow section; and (h) kinematic viscosity of water-portion of the waste. Each of these factors is described in some detail.

An example of the design of an actual separator, including accessories, is given in detail. This example is too lengthy for inclusion in an abstract; the original article contains graphs and data sketches which are used in finding the solution to the design problem.

RICHARD D. HOAK

Chemists Make Soluble Food Casings from Wastes. *The Canner,* **104**, 26 (May 17, 1947).

A new pectinate material is made from citrus peel or apple pomace and is used as

a soluble protective coating for sausage and other meat and food products.

If the coated product is boiled the film is dissolved or if fried or roasted the film may be consumed with the meat as it is tender and edible.

H. GLADYS SWOPE

The Fishes of the Willamette River System in Relation to Pollution. By R. E. DIMICK AND FRED MERRYFIELD. Engineering Experiment Station, *Bulletin Series* No. 20, 58 pages, Oregon State System of Higher Education, Oregon State College (June, 1945).

This study, to list the various fishes inhabiting the river and to ascertain the general effects of pollution on the game and commercial species, was authorized, June 30, 1944, as one phase of a comprehensive survey of pollution conditions.

Sampling points were established on the main river and on important tributary streams. Usually, the sampling stations were located above and below focal points of major pollution and in relation to the confluences of tributary streams flowing into the main river.

Hydrographic data, chemical characteristics, bacteria counts, collections of fish-food bottom organisms and fish collections were obtained at each sampling station. Data on water temperatures, dissolved oxygen content, biochemical oxygen demand and pH are summarized in this report. The highest water temperature recorded was 89° F. No trout, salmon or whitefish were found in this high water temperature. Temperatures of this magnitude would probably be lethal to these fish. On the other hand, large mouth bass, pumpkinseed sunfish, blue-gill sunfish, white crappie, bullhead catfish and carp did not appear to be distressed. No salmonoid fish was observed in water 73° F. or above. In the majority of cases, cutthroat trout, rainbow trout and Chinook salmon were observed and collected during August and September in waters having a temperature range of 55 to 66° F. They were always less numerous in water ranging from 67 to 72° F. Large mouth bass, bluegills, black and white crappie and pumpkinseed sunfish were obtained during August and September in water ranging from 59° F. to 89° F. None of these fish were found during these months in water 58° F. or below. In one case numerous bullhead catfish were obtained in an isolated pool along the river at 93° F.

Generally, in water of low oxygen content for the species, the breathing rate is increased, and under such circumstances the toxicity to the fish of poisonous materials may be greatly intensified. No live trout or salmon were found at any time during August and September in water having less than 5.2 p.p.m. dissolved oxygen. The majority were collected in water ranging from 7.8 to 10.6 p.p.m. A group of cutthroat trout, rainbow trout and fingerling Chinook salmon were maintained in good health for 30 days in experimental tanks having a D.O. content of about 5 p.p.m. and a temperature of 60 to 70° F.

The B.O.D. of the river was sufficiently high so that D.O. contents of 0.0 p.p.m. were found on several occasions. Two outstanding pollution areas receiving sulfite liquor wastes from pulp mills had low D.O. contents and gave evidence of toxicity to fish and fish-food organisms.

The pH of the river water varied from 6.1 to 7.9.

The kinds of fish present, their locations and relative abundance in the Willamette River System are tabulated. Thirty-four kinds of fish belonging to 13 different families were found. At least 19 of these were of game or commercial importance. Some of the 15 minor fishes may have important bearing on recreational and commercial species as competitors, as predators, and as food for these desirable fishes. Twenty-three species were indigenous and 11 were exotic. A list of the fishes found is given along with their technical names, some pictures, and informative notes relative to their life history, occurrence, etc.

Important organisms in the diets of rainbow, steelhead and cutthroat trout are the aquatic insects, mayflies, stoneflies, caddis flies, midges, blackflies; insects of terrestrial origin; crayfish and fish. Pictures of some insects are included. A summary is given of the kind and numbers of fish-food organisms obtained at sampling stations during August and September. Stonefly nymphs appear to be the least tolerant of pollution and in only one case

were found in water suspected of pollution. Mayfly nymphs and caddis fly larvae could not be found below a flax retting plant and other locations. The dissolved oxygen content of the water appears to have some influence on the presence or absence of these organisms. In areas of pronounced pollution from sulfite liquor effluents and cannery wastes, midge larvae and aquatic annelids (slugworms) were usually present in significant numbers, but the important insect groups were absent. Silt deposits destroyed bottom organisms in some areas. In certain areas the scarcity of fish in species and numbers may be the result of food depletion in amount and kinds resulting from the effects of pollution in that area.

The authors conclude that untreated pollutants from many and varied sources have at times killed desirable fishes by depleting the oxygen supply of the water and that toxic action of some effluents is a major cause of fish and fish food decreases in various areas. Portions of the river system are seriously affected by pollution, especially during the season of low water volume. Pollution as it now exists in parts of the river system is one of the most serious contributing causes of unsatisfactory fish habitat. The authors suggest that 5 p.p.m. become the lowest D.O. for satisfactory fish habitat, that no waste water effluent toxic to fishes and their preferred foods be discharged into the river and that a biological index of suitability by determining the presence of mayfly nymphs, caddis fly larvae, and stonefly nymphs be provided.

ROY WESTON

Professional Opportunities

Bacteriologist

Graduate Bacteriologist to take charge of section in newly organized research project in Eastern United States; must have some background in chemistry and experience in the field of sewage and water research or treatment; salary $3,200 to $4,200 depending upon qualifications. Write Dept. AAR, Federation of Sewage Works Assns., 325 Illinois Bldg., Champaign, Ill.

Sanitary Engineer Officers

The War Department has been requested by the Eighth Army in Japan to select a number of Sanitary Engineers to serve in the various prefectures and special areas in Japan as Sanitary Engineer Officers.

Duties

1. Under the supervision of the Military Government Officer, each incumbent will supervise the work of one sanitary technician, administratively and technically. He will have the responsibility for the surveillance of the civilian sanitarian program in his region or special area.

2. Surveillance of Japanese officials in the Sanitation Department of the region or special area with regard to these activities: (a) Organization, training and operation of civilian sanitation squads for insect and rodent control and environmental sanitation; (b) Investigation of outbreaks of communicable disease, making sanitary surveys and recommending to the commanding officer of the Military Government the sanitary measures necessary for the control of such diseases; (c) Inspection of all matters pertaining to construction, repair and operations procedure of civilian water works, waste collection and disposal installations; (d) Other general and specific duties relative to sanitation as the situation may demand.

Qualifications

1. Graduate in Sanitary or Public Health Engineering, or graduate in other branches of engineering, plus one year of experience with a public health unit or the USPHS or experience equivalent to these qualifications. Must have a working knowledge of the activities set forth as duties.

2. In view of certain working and living conditions peculiar to this theater, it is desired but not mandatory that preference be given to qualified applicants who possess all or most of the following additional qualifications: (a) In the age group 30–45; (b) Willing to serve in isolated areas; (c) Strong enough physically to make inspection trips under difficult travelling and weather conditions; (d) Men who have had some military experience and/or administrative experience; (e) It is almost mandatory that unmarried men be recruited for these positions since the present policy in Japan in connection with the transportation of dependents overseas precludes the possibility of civilian employees in the grade of P-4 or its equivalent and below from bringing their families to Japan.

Salary

These positions have been established at a Civil Service rating of P-4, the base pay for which is $4,902. This base pay will be augmented by a 25 per cent overseas differential, making a total annual salary of $6,127.50.

Apply

D. Donald Klous, Major, GSC, Branch Executive, War Department, Civil Affairs Division, Personnel and Training Branch, Washington 25, D. C.

Engineers

Civil, sanitary, electrical, mechanical, refrigeration and air conditioning engineers are needed to fill overseas positions with the U. S. Army Engineers. Positions are available at Guam, Philippine Islands, Okinawa, Japan, Korea and in the Caribbean Areas; salaries range from $3,306 to $8,875 per annum; housing for dependents is not generally available. Apply: Civilian Personnel Branch, Office of the Chief of Engineers, Building T-7, Gravelly Point, Virginia. Applications should include completed Form 57, U. S. Civil Service Commission, in duplicate, copies of which can be obtained at your local post office.